PRODUCT ENGINEERING

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A Time for Drastic Change

MUCH of our progress in product design is in the nature of relatively slow evolution rather than in drastic departures from accepted practice. There are two good and sufficient reasons for this situation: the fact that customers hesitate to buy something new and untried, a product that is different from the things to which they have grown accustomed; and the expense involved in the replacing or changing over of heavy concentrations of manufacturing equipment much of it probably unsuited to the specifications of the new product.

But there are periods when these two factors resisting change are less forceful than usual. Such a time came after the war when public psychology suffered a violent reaction from the tension of the struggle and the public taste turned to things that were hardly popular prior to 1914. At the same time many manufacturers found themselves with wornout equipment or equipment that was suited only to munition making. When they re-equipped they were quite willing to consider radically different products because they had to have new machinery anyway.

The designing engineer should study the current situation to see if we may not again be facing something somewhat similar. The public is certainly sick of economizing and anxious to buy new and better things when it gets some ready cash. Manufacturing equipment has run down to the point where much of it is utterly useless. Replacements on a large scale will have to be made before long.

Evidence that the present is a time for drastic change is given by the new units recently ordered by steam and electric railroads. If there was ever a field in which development is cautious it is the railroad field. One has but to compare speeds of today and of a generation ago to prove this statement. Yet all of a sudden we get word of an all-aluminum, high speed articulated train for the Union Pacific and a corresponding stainless steel one for the Burlington. Simultaneously the street railways develop a silent, speedy, comfortable street car and an elevated road orders an articulated light-weight train. Such evidence, if not absolutely convincing, is at least worth considering. If it indicates a general trend, busy times for product engineers are at hand.

Commodity Prices

REGARDLESS of the cause of the rise in commodity prices, the fact that they are rising is a concern of the designing engineer. Assuming that his present choice of materials has been made on a careful analysis of relative cost there is little reason to consider changes or substitutions on the basis of price unless the current balance is disturbed. But if one or two metals suddenly shoot up faster than some others then the question of substitution becomes a live one.

To take a practical case, so long as steel is relatively much less expensive than brass the higher cost of machining a steel part may be offset by its lower cost per pound. But let this differential in cost change appreciably and it may well be more economical to specify the more expensive but also more cheaply fabricated materials.

Many factors, domestic and foreign, commercial and political, will modify commodity prices in the next few months. Designing engineers will find it the part of wisdom to watch them carefully.

Courtesy American Brass Company

With the elimination of machining operations, bronze die-castings instead of sand castings can be used economically in quantity production

Six Competitive Types of Castings

A method of procedure to determine which type of casting is most economical to use for a given part

D. BASCH, *Works Laboratory, General Electric Company*

WITH the continuing development of new materials and new manufacturing methods, the problem of obtaining a design that will give adequate service and performance in combination with lowest cost demands that the engineer organize his information in detail. It becomes necessary for him to arrange his design procedure so that there is no chance of overlooking any suitable method or material. One such design procedure is to collect in tabular form all the available processes and to arrange the information so as to emphasize controlling factors in the choice of each process. The data presented here, applying to casting methods and casting materials, are arranged in accordance with this plan.

A satisfactory product is recognized as one in which each part, both by itself and when assembled with other parts, meets all the physical, chemical and operating requirements of service. Total cost includes cost of basic materials, cost of preforming the part, and cost of finishing to final dimensions. To obtain best results in service in combination with lowest cost, three factors of the design problem are considered together: design, material, method of manufacture.

Coordination between these three elements is assured by proceeding in the following steps:

1. Establish the general service requirements, decide on the general design to meet these requirements, and rough out each part of the unit to fit into the general design.

2. Determine the probable production requirements for the first order and for normal production.

3. Consider all materials which meet the physical, chemical and electrical requirements, and consider all manufacturing processes that can be used.

4. From the third step select the combination of material and process that gives the best mechanical and commercial results for the prospective production. Then complete the detail design.

Production requirements must be taken into consideration in the selection of material and process. In low production with manufacturing methods requiring a great deal of machining, it may be more economical to use an inherently more expensive material with good machining qualities rather than a lower cost material that is more difficult to machine.

On low and medium production parts, availability of the material is also a factor. Is the material in the required form and size readily available or must it be ordered especially for the job? An inherently more expensive material readily available in the plant may be cheaper than a less expensive material that is not at hand.

Shape and proportion of the parts will be influenced through the mechanical and manufacturing properties of the material selected, and the design will also vary with the manufacturing process. It is important, therefore, that the design proceed hand in hand with the selection of the material and the process. Although this selection is the responsibility of the designer, consultation and cooperation with manufacturing departments is indispensable.

As a convenience to the designer, the following list

includes the more common manufacturing processes for forming raw material into the required shape, ready for finishing and assembly:

1. Castings: (a) sand castings; (b) metal mold castings: permanent mold, semi-permanent mold, moderate and high-pressure, centrifugal.

2. Hot-forming operations: (a) forging: hammer, drop forging; (b) hot pressing; (c) hot extrusion; (d) hot upsetting.

3. Cold-forming operations: (a) punching and drawing; (b) spinning; (c) swaging; (d) extrusion; (e) upsetting and pressing.

The following finishing operations are available:

1. Changing shape and dimensions: machining, cold planishing.

2. Change of surface: (a) sandblasting, scratch brushing, tumbling, pickling, grinding; (b) polishing, buffing.

3. Protective coatings: Painting, plating, sherardizing, Parkerizing, Bonderizing, hot dip galvanizing, hot tin dip, Schoop gun spraying, anodizing, calorizing, enameling.

In assembly two methods are available:

1. Metallic bonding: Soldering, brazing, welding.

2. Mechanical joining: Riveting, bolting, clamping.

Of the various casting methods, sand casting is still the most common form, requiring the lowest tool cost and the shortest time to get into production. Also, sand casting is the most flexible method in regard to limitations in size, weight and alteration of tools, but it involves more direct labor in foundry and machine shop. As compared with metal-mold castings, physical properties and structural density of sand castings are subject to greater variation, and the surface has a rougher finish. In general, sand casting is used where production considerations do not justify metal-mold castings or any of the other high production manufacturing methods.

Sand castings are subject to certain defects which may be minimized by proper design and care in casting, but these defects are not entirely preventable nor predictable. Internal blow holes or shrink holes may be present, even though the casting appears to be sound. A higher factor of safety must be used for sand castings than for metal-mold castings, especially where the part is highly stressed or is responsible for safety of operation. Because of the surface imperfections and variations in wall thickness in sand castings, more stock must be left for machining. Consequently a heavier wall section is required, and in addition machining may be required on a sand casting where the surface of a metal-mold casting or a forging would be sufficiently smooth.

Included among the various types of metal-mold castings are: permanent molds, moderate-pressure die-castings, high-pressure castings and centrifugal castings. Since each of these processes has characteristics that limit its application, final selection of the casting process must take into consideration the suitability of the material, the physical and mechanical characteristics as well as the publicity value of the process, and the total cost of the finished piece, including the cost of tools. Metal-mold castings have higher strength, better surface appearance, closer tolerances and are lower in labor cost than sand castings. The chief disadvantage in the use of metal-mold castings is the higher tool cost.

All metal-mold castings, with the exception of centrifugal castings, lend themselves well to the use of inserts: preformed and finished parts, such as screw machine parts and punchings. Inserts make it possible to use special materials at certain points for bearings, insulation, magnetic or conducting paths, and also make possible an inexpensive and reliable assembly of several parts that as a one-piece design would be complicated and expensive.

In making permanent-mold castings the fluid metal is poured by hand into metal molds and around metal cores without external pressure. This method can be used with aluminum and its alloys and, under certain conditions, with cast iron and with some of the brasses and bronzes. Permanent-mold castings produce a dense, fine-grained structure free from shrinkage cracks or blow holes. Except in heavy sections, the castings have uniform properties from the outside to the center, and the surface can be given a high uniform polish. In addition, tool charges are relatively low. Permanent-mold castings are used in competition with hot pressings, drop forgings and centrifugal castings, for moderate and high production parts demanding freedom from porosity with good surface, and when there are but few close tolerances.

Semi-permanent molds differ from permanent molds only in the use of sand cores instead of metal cores where cored openings are irregular in shape, or large and deep. The advantage of metal-mold castings in holding dimensions to close tolerances, and in producing smooth surfaces exist only in the sections cast against the metal mold. Structure, tolerances, and surface conditions around the sand cores are the same as those in sand castings. Tool cost for these castings is

Zinc die-castings are used in one of the newer designs of General Electric fans. When smooth and accurate surface curvatures are required, die-castings are ideal

somewhat lower than with permanent mold castings and the production rate is somewhat slower. Semi-permanent mold casting is the most flexible of all the processes, extending the advantage of metal-mold castings to many parts not suitable for permanent molds or die-castings.

In moderate pressure die-casting, fluid metal is forced under pressure into metal molds. Lead, tin, aluminum, aluminum alloys containing more than 2 per cent iron, and zinc-base alloys can be used. This method produces castings with close tolerances, sharp outlines and smooth surfaces, and is adaptable to high production rates with low labor costs. Die-casting requires thin sections, particularly with aluminum alloys, to prevent shrink holes, although heavy sections can be used if moderate porosity is not objectionable. Trapped or dissolved air in die-cast parts may cause blisters on the surface if the parts are subjected to high temperatures. Chilling in the mold produces a strong skin on die-castings, so that deep machining or polishing that removes the chilled surface reduces the strength of the section. Warping may follow if more than 0.010 in. is removed. Castings to be plated should have a smooth surface so that deep buffing will not be required.

Moderate pressure die-casting is used for moderately high and high production parts requiring a high grade finish, sharp outlines, close tolerances, but not requiring high strength or structural density. This method is used in competition with permanent mold and high pressure castings and punchings where one die-casting can take the place of several parts.

In high pressure castings, metal in a pasty or semi-fluid condition is poured by hand into metal gates, and forced into the mold under high pressure. Zinc and zinc base alloys, aluminum and its alloys, and certain brasses and bronzes can be used. High pressure casting produces brass and bronze parts with smaller tolerances and sharper outlines than can be secured with permanent mold castings. Also, aluminum alloys with low iron content and many zinc alloys can be molded at a high rate of production and with good structural density. As experience with this method is limited, casting size for the present is limited to 5 lb. in aluminum and 15 lb. in brass. High pressure casting takes the place of moderate pressure die-casting for brass, bronze, aluminum, aluminum alloys with low iron, and zinc alloys without aluminum.

Centrifugal castings are made by pouring highly fluid metal into revolving metal molds. In the more common shapes, such as rings or tubes, the molds are rotated around their own axis. Other compact and small shapes can be rotated along the perimeter of a circle concentric with the axis of rotation. Aluminum and its alloys, brasses, bronzes with low lead and tin, cast iron, and cast steel can be used. Centrifugal casting produces a dense structure free from porosity, and in castings with a hole through the center there is no limitation as to size or length. Sound castings can be produced in long pieces from which the required lengths can be cut. Close tolerances and sharp outlines are obtained only at the periphery, so that extra metal must be left on the wall of the center hole for machining. In general, centrifugal castings are used for parts having a through hole in the center and where freedom from structural porosity is required. This method is used in competition with extruded sections, rods and tubes, pipes fabricated to shape, hot pressings and permanent-mold castings.

In the accompanying table the characteristics of each of the casting methods are compared on a competitive basis. After setting up service and production requirements for the part being designed, the table can be used to select the casting material and casting method that is most suitable and economical.

Relative Characteristics of Different Casting Methods

(Numbered in order of preference)

Casting Method	Sand Cast	Permanent Mold	Semi-Permanent Mold	Die-Castings Moderate Pressure	Die-Castings High Pressure	Centrifugal Cast
Casting Materials	All Casting Metals	Aluminum Alloys Brass, Bronze, Iron		Lead, Tin, Zinc Alloys Al Alloys*	Zinc Alloys Al Alloys Brass, Bronze	Al Alloys Brass, Bronze Steel, Iron
Minimum porosity	6	2	5	4	3	1
Surface smoothness	6	4	4**	2	1	3**
Sharpness of outlines						
Tolerances						
Unit strength	6	4	5	2	1	3
Uniformity across section	3	1	4	6	5	2
Thinness of section	6	4	5	2	1	3
Pattern or tool cost	1	4	3	5	6	2
Production rate, Labor cost	6	3	4	1	2	5
Machining required	6	3	4	2	1	5

*Except aluminum alloys with less than 2 per cent iron.
**Only for the surfaces cast against the metal mold.

In permanent mold zinc "slush" castings no core is used. After the molten metal in contact with the walls of the die has been chilled, the remaining fluid metal is poured out

PRODUCT DEVELOPMENTS

Features of the design of the new Seversky airplane—Rubber mountings in railway cars—New German motorcycle—Large welded cable reel—Stainless-clad milk truck tank—New developments in the design of turbine pumps

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▸ New Seversky Aircraft Design

Perhaps the most novel feature of the new Seversky aircraft is the interchangeable amphibion landing gear. This is in reality a universal landing gear since the construction is such that the plane can land on ice and snow as well as land and water.

The accompanying picture clearly shows the construction of the floats with the retractable wheels which fit in a slot cut through the float from the deck to the keel. With the float down, and the wheel up, the latter lies wholly within the float boundary. A radical departure from previous attempts at wheel-float combinations is that no closure is provided at the well bottom. This feature of the design has been subjected to some criticism but tests have indicated that the running and take-off characteristics have not been impaired.

Each float is pinned to the free end of its strut, swivelling freely in a vertical plane parallel to the plane of symmetry. The smaller strut aft acts as a guide and as a means of locking the floats down in the water landing position.

For landing on water, the wheels are retracted into the floats by a hydraulic gear, the upward travel of the wheels operating a cam which actuates a locking device to pin the sliding blocks in the rear strut supports fast to the pontoon structure. The floats are then rigidly connected to the airplane in the normal manner. For ground landing, the wheels are extended through the bottom of the float, the locking pins in the rear strut connections being withdrawn automatically.

Other features of the design are the all-metal construction, welded steel tube engine mount, rubber vibration absorbers between engine mounting and fuselage, all controls equipped with ball bearings.

Seversky all-metal amphibian powered with a 700-hp. Cyclone engine, and capable of a top speed of 260 mi. per hr.

From the commercial aspects of the design, probably the most important feature is that the major part of the ship can be produced by automatic machinery as the ship is free from spars, ribs or longerons which inherently complicate subassemblies.

As an example, in the wing construction the smooth outer skin is reinforced with corrugated sheets on the inside running along the span. The bottom skin is stiffened by channel sections forming a closed box section extending the length of the skin. With this design, the entire top and bottom skin can be finished completely by automatic machinery and then assembled into the wing.

▸ Rubber Mountings

In the experimental railway car truck developed by the engineers of the Railway Presidents' Conference Committee under the direction of Prof. C. F. Hirshfeld, approximately 180 lb. of rubber is used, which supplies virtually all of the springing. Design of the wheels is similar to that of the wheels on the Autotram built recently by the Clark Equipment Company. Annular rubber disks are held mechanically between each of the outer web plates supported by the hub, and the central wheel-disk that supports the rim. Annular rings or grooves turned into the surfaces of these plates hold the rubber disks firmly in place, the latter being serrated to correspond to the groove in the web plates and wheel disk.

Other rubber mountings include

axle mountings, axle bearings suspended on rubber and side bearings on which the car body is supported. These last are composed of alternate blocks of rubber carried in shear between the upper and lower supports.

▸ New German Motorcycle

From Germany comes an unusual design in motor cycles, a development of the Bayer Motor Werke, of Muenchen. Many features of this machine closely follow modern practices in automobile design, as can be seen from the accompanying illustration of the model R-16. For example, a single-dry-disk clutch and three-speed transmission form an integral unit with the engine. From the transmission the drive to the rear wheel is through a drive shaft which carries the service brake at the rear of the transmission. The rear wheel drive is through a spiral bevel gear running in oil.

The engine has two horizontally opposed cylinders, slightly offset, and firing together; a type of design to which is attributed smooth running and freedom from vibration. Separate carburetors with air cleaners are provided for each cylinder. Forced feed lubrication, inclosed overhead valves, roller bearing crankshaft and connecting-rod bearings are used.

With a displacement of approximately 65 cu.in., the motor is said to develop 33 hp. at 5,600 r.p.m., giving the machine a road speed of 110 m.p.h. A factor which contributes to the exceptional performance of this motor is the transverse arrangement of the cylinders, affording better cooling than the conventional in-line design.

The chassis, including the front fork, is built up from pressed steel channel sections. The front wheel, carried on tapered roller bearings, has a completely inclosed internal expanding brake, and is suspended on leaf springs.

That the machine weighs only a little more than 300 lb. is no doubt because of the liberal use of aluminum alloys. The appearance is particularly pleasing because of the absence of chain guards, valve linkage, miscellaneous control rods and levers.

▸ Bonderized Beer Kegs

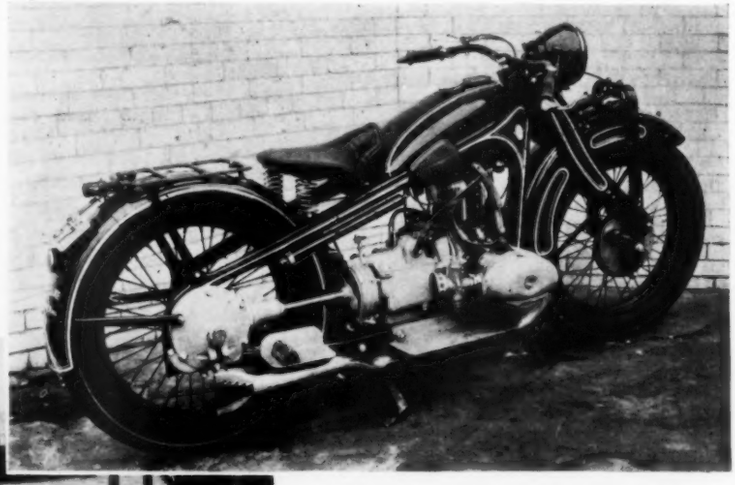
Any beer keg, whether wood or steel, requires a pitch lining to retain the taste and flavor of the beer. One of the great difficulties in the manufacture of steel beer barrels is to make the pitch lining adhere to the metal. Only slight vibrations will loosen the pitch.

In their development of steel beer barrels, the Murray Corporation of America resorted to Bonderizing the barrel inside and out. This Bonderized surface serves as a base for the pitch lining on the inside and the baked enamel outer finish. When being applied, the plastic pitch penetrates the Bonderite coating, thereby fastening itself securely to the metal. Similarly, on the outer surface the baked enamel gets a firm anchorage, preventing cracks and chipping off.

▸ New Turbine Pumps

Two unusual design features are incorporated in the new line of turbine pumps recently announced by the Roots-Connersville-Wilbraham Company. One of these is a modification of the well-known turbine principle. The edge of the impeller is tapered, fitting into a corresponding taper in the pump casing. An adjusting screw that can be turned from outside the pump casing while the pump is running, shifts the impeller axially, thereby varying the capacity of the pump and resulting in a reduction of power consumption.

The other unusual construction is



Several unusual design features are incorporated in this BMW model R-16 motorcycle, a German product

The insulated milk tank on this truck is built of No. 10 gage stainless clad steel, with all seams butt welded and ground smooth on the inside. Outside jacket is 20-gage auto-body steel, all seams are welded. Rungs on the ladder are stainless steel. It is a product of the Alloy Products Corp.

the seal-type packing gland which rotates with the shaft. This feature makes it impossible to score the shaft as might happen when the shaft rotates in a fixed stuffing box. Also, less frequent repacking is required.

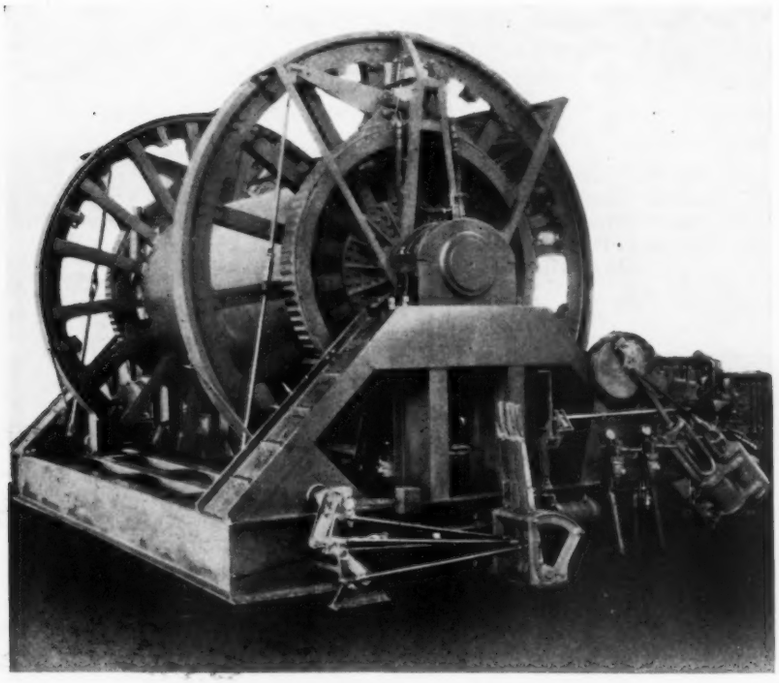
▸ Welded Cable Reel

In the design of a submarine cable reel developed by engineers of the Pacific Telephone & Telegraph Company and built by the Washington Iron Works, it was required that the machine must be sufficiently portable so that it could be hauled ashore on skids when not in use. The construction of this unusual design of reel is shown in the accompanying illustration.

No rivets are used for connecting members, the whole machine being either welded or bolted. The drum spool is 80 in. in diameter and 14 ft. in length.

Probably the most interesting feature of this design is the construction of the brakes. The specifications called for a maximum of 50,000 lb. line pull when the drum is turning at a maximum speed of 16 r.p.m. To control the brake forces and energies involved, the type of brake adopted is similar to the type which has been used successfully on logging engines in operation on the Pacific Coast. The brakes are 102 in. in diameter and 10 in. face width. The brake lining is fastened to the rotating brake drum. The bands are made of steel with a corrugated cover welded on the outside, thereby forming tubes through which cooling water is circulated.

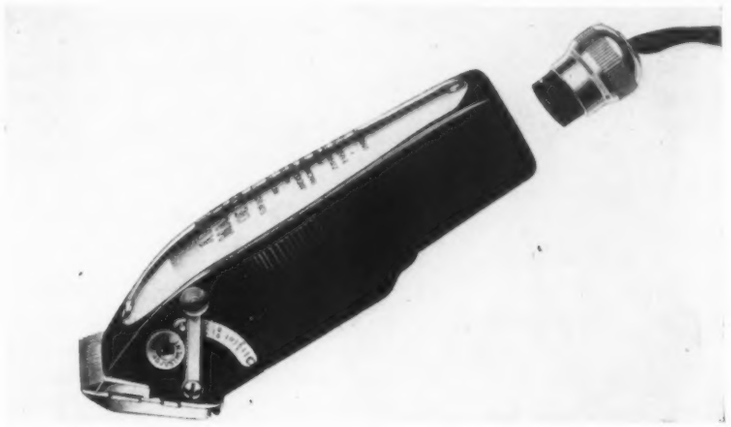
Weight of the complete unit is 65 tons. The design calls for letting out cable at the rate of 500 ft. per min. and picking it up at the rate of 200 ft. per min. When in operation, it is placed on a barge and towed to the scene of repairs.



Water-cooled brakes and all-welded construction feature this unusual 65-ton cable reel. Used in repairing marine cables, it had to be designed light enough so that it could be readily put on and taken off a barge

▸ New Applications of Alumilite

Recently reported adoptions of the Alumilite process for coloring aluminum include the filling mechanism of the Parker pen. In this application the colored Alumilite coating is used on a machine threaded part, this necessitating a finish that would not materially change the close tolerances and would be resistant to thread wear.



Electric hair clipper with aluminum die-cast body colored by the anodic treatment

The Tefra Company has adopted Alumilite coatings for die-cast aluminum tooth brush handles finished in a variety of colors and also finished with names and initials inscribed on the handle.

In the electric hair clippers manufactured by the Andis Clipper Company, the body of the clipper is an aluminum die-casting to which the Alumilite color coatings are applied. According to the manufacturer, the finish is not subject to chipping or flaking, and as the color is sealed within the coating, the finish will not stain. Colors used are black, blue, green, and maroon.

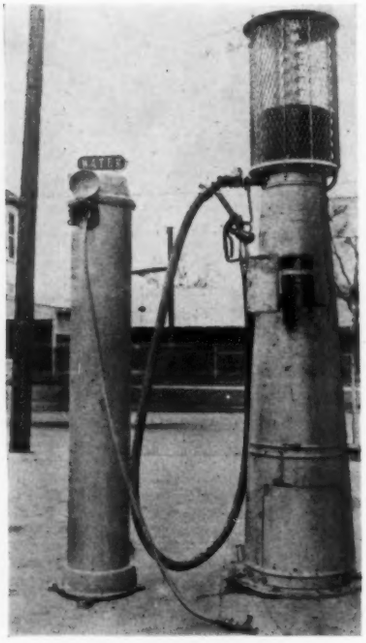
The primary purpose for the adoption of Alumilite on stocking inspection forms used in silk hosiery mills was to overcome the tendency

of aluminum to discolor the undyed stockings and to become "tacky." Also, the possibility of selecting different colors made it easier for the inspectors to detect imperfections.

▸ New Service Station Equipment

The Alamo Iron Works developed the equipment shown here for supplying normal-temperature water for automobile radiators. Insulation between the outer and inner steel shell of this "water cabinet" serves to minimize the heat losses, thereby making it economical to maintain the water at a normal temperature by means of an electric heater element in the base of the column. The whole interior of the column is maintained at a predetermined uniform temperature, the electric heating element being controlled by a thermostat, this serving to maintain the water in the column at the desired temperature.

The base of the column is cast iron, the cap is aluminum. The pulleys on which the rubber filling hose is reeled are mounted on ball bearings. A small thermometer protruding from the top of the cap indicates the water temperature, acting as a check on the thermostat setting. At the back of the column is an indicator light that serves as a tell-tale on the action of the thermostat.



Electrically heated and insulated water-dispensing cabinet—a new piece of service station equipment for dispensing warm water for automobile radiators

▸ Increased Capacity in the Same Space

Symmetrical designs are so universal that one is apt to lose sight of the possibility of saving space by unsymmetrical construction. In the No. 2 Brown & Sharpe automatic screw machines the clearances are such that the permissible diameter of the dieheads used is limited.

Practically all self-opening dieheads have bodies, sleeves and other parts essentially cylindrical in shape. In the development of the H & G self-opening diehead for this machine, the Eastern Machine Screw Corporation's engineers aimed to design a self-opening diehead that would permit threading up to 1-in. diameter threads, and yet retain the construction as in the previous design to make it possible to use the same chasers as used in all 1-in. sizes of their H & G dieheads.

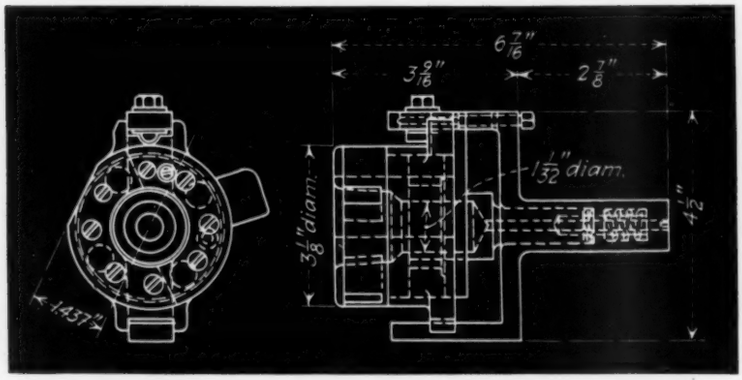
By slabbing off one side of the diehead, as indicated in the accompanying drawing, and making a few other incidental changes, the desired result was obtained.

▸ New Radio Cabinets

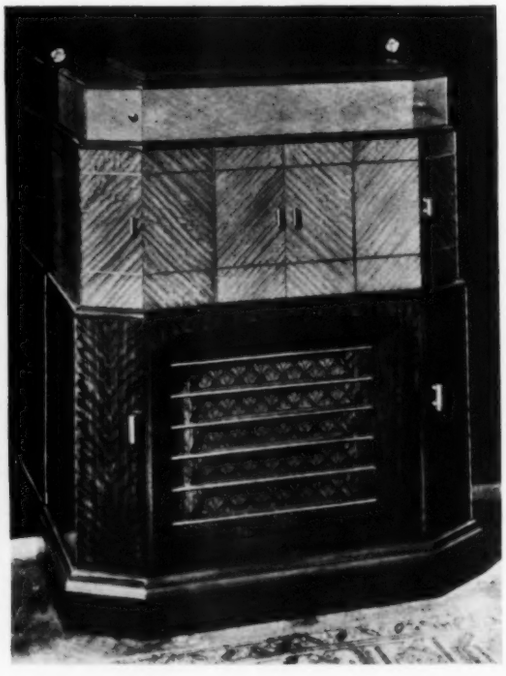
Illustrated herewith is the 15-tube, Scott all-wave radio equipped with Jensen speaker, Capehart automatic record-changer phonograph, and a condenser microphone for making individual records in the home. The radio was designed for world-wide reception.

Arthur Charles Haggstrom, industrial stylist, designed the Imperial Grande cabinet which houses this radio. The base of the cabinet is made of oriental walnut, the speaker section of figured walnut, the radio section of satinwood, and the phonograph section of bird's-eye maple. The hardware is chrome-plated steel with satin finish.

Imperial Grande radio cabinet designed by Arthur Charles Haggstrom for the E. H. Scott Radio Laboratories



By deviating slightly from traditional symmetrical construction, the capacity of this diehead was increased without increasing limiting dimensions



PHOTOCELLS

The three types, their operating characteristics, respective advantages and limitations, and the auxiliary electrical equipment that is required in making photocell applications

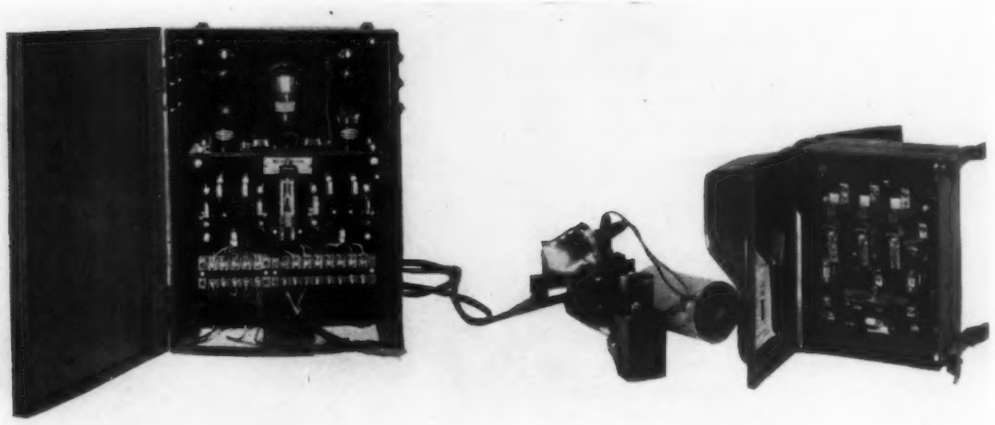


Fig. 1—Registering of a paper cutter with printing on the paper is accomplished by this Westinghouse photo-electric control. Light source and photocell in the center, electronic amplifier and relays in the cabinet, contactor switch on the right

IN THE application of equipment and devices for photo-electric control, the initial problem is to select the most suitable one of the three general types of photocells available, and the type of auxiliary equipment to use. With each of the three general types of cells, photo-voltaic, photo-emissive and photo-conductive, it is possible to use a wide variety of auxiliary equipment such as amplifiers, relays, contactors, switches and transformers, depending on the nature of the response required.

Without going into the theory of its operation, the photocell can be considered to be a generator or controller of electricity, deriving its power from the energy of light. That is, light falling on the plate or light-sensitive element of the photocell causes a change in the flow of current in an external circuit. Thus, to operate the photocell it is only necessary to interrupt a beam of light. No energy is required to interrupt the light beam; there is no physical contact between the material bodies involved. It is this characteristic that results in many of the unusual applications of photo-electric controls.

Other features of the photocell include high-speed response and the absence of mechanical inertia, mechanical unbalance, and also the absence of fire hazards from exposed contacts as there is no mechanical making or breaking of the control circuit. In the application of each of these types of photocells to mechanical operations, there are two general classes of service: positive response to a light beam of constant intensity, and variable response in proportion to the intensity or color of the light beam.

Probably the most elementary application of photo-electric control is that in which a positive actuation is given when light strikes a photocell or when the illumination is interrupted. For example, in paper mills a break in the paper web is indicated; in steel mills soaking pit covers are operated by a light on the crane cars directed on overhead photocells. In modern elevators, light beams projected across the entrance are focused on photocells so that the doors cannot close while the light beam is interrupted. Mine doors are opened and closed automatically, the register of draw bridges is indicated with photocells.

Photo-electric equipment is in use counting automobiles, sheets of paper, lamp bases, logs in a paper mill, and on conveyors to count articles that are too light to operate switches. In counting hot ingots, plates and shapes in a steel mill, the high temperature of the metal destroys contact fingers in a few hours.

Of the three types of photocells, the photo-voltaic cell provides the simplest type of control. The photo-voltaic cell consists of a copper disk 1 to 2 in. in diameter with a layer of copper oxide on the light-sensitive face. As illustrated in Fig. 2, the disk is usually mounted in a case of some insulating material such as bakelite, with the light-sensitive face of the disk exposed. Light falling on the sensitive face generates a voltage between the copper and the light-sensitive layer, causing a flow of current. No external

battery or amplifier is required. A low resistance, sensitive, meter-type relay having less than 1,000 ohms resistance can be operated directly by the photocell current. Relay contacts can be so arranged that they are normally open or normally closed to control the secondary circuit when the photocell is illuminated or when the illumination is interrupted. A suitable housing must be provided for the relay for protection from vibration, dirt and moisture. For the light source either natural light or artificial light from an automobile headlamp or any other concentrated filament lamp focused by a single lens upon the photocell is used. The lamp may be placed any distance up to 15 to 20 ft. from the photocell.

The advantages of the photo-voltaic cell over other types for positive response is in the simplicity of the control, small space requirements, and low maintenance expense. Also, the cell becomes more sensitive with increasing illumination.

Because of the high sensitivity required of the relay used with these cells, only circuits limited to a few watts power can be operated directly. The low resistance of the voltaic cell makes the use of electronic amplifiers impractical so that amplification can be obtained only through multiple relay stages. When multiple relays are required the operating time is increased by the lag in the response of the relays. Also, the current output of the photocell becomes less as the duration of the light flash decreases. For these reasons the photo-voltaic cell is not suitable for application requiring extremely high speed response. The ambient temperature range in which the voltaic cell can be used is limited, and the cell also has a considerable temperature coefficient.

Photo-emissive cells, the second type of photo-electric tube, can also be used for positive actuation. The photo-emissive cell or phototube has a light-sensitive plate or film spaced $\frac{1}{2}$ in. or more from an anode or conducting wire, both inclosed in a glass tube. The phototube requires an external circuit with a resistance of several megohms and a d.c. potential of 20 to 90 volts or more across the conducting path in the tube

Phototubes are available in two general types, vacuum and gas filled. The vacuum cell under constant illumination gives an output that is but little affected by potentials above 20 volts, and can be safely used with a potential of 300 to 400 volts. The gas-filled tube cannot be safely operated at more than 90 volts, but the current obtained from the gas-filled photocell increases as the voltage is increased above 20 volts. At 90 volts the gas-filled tube gives about five times the voltage output of a similar vacuum cell under the same conditions.

Phototubes are available in a variety of sizes from $\frac{1}{2}$ in. diameter and 1 in. long to large bulbs a foot or more in diameter. Tubes used in most industrial applications are about the size and shape of a radio tube, and are usually mounted on a prong base similar to the base used for radio tubes. In Fig. 3 is shown a typical phototube.

The power from the phototube is produced by a high voltage and an extremely small but stable current as contrasted with the voltaic cell having an output with relatively low voltage and high current influenced by temperature. Although the power output of the phototube is greater than the power obtained from the voltaic cell, electromagnetic relays cannot be operated directly because of the impossibility of making an electromagnet with enough turns of wire to operate on the small current obtainable. However, electronic amplifiers capable of operating relays can be controlled by the small currents from the phototube. In addition, by successive stages of electronic amplification it is possible to operate directly counters, switches, electromagnets, or other devices requiring considerable power. Grid controlled rectifier tubes can also be used to step up the output of the phototube. Such rectifier tubes are available with sufficient capacity to operate directly small motors, magnetic switches, clutches, brakes or other devices requiring up to 500 or more watts power. When used with electronic amplifiers the sensitivity is greater at low illumination.

The response of the phototube is practically instantaneous, with no reduction in the output even when the duration of the flash of light is as short as 0.0001 sec. The total time lag between light impulse and the start of current flow in the circuit operated by a grid controlled rectifier tube is 0.001 sec. or less when the control circuit is d.c. The use of the phototube with either the electronic amplifier or the grid controlled rectifier tube in a d.c. circuit provides an extremely high speed combination, the highest obtainable.

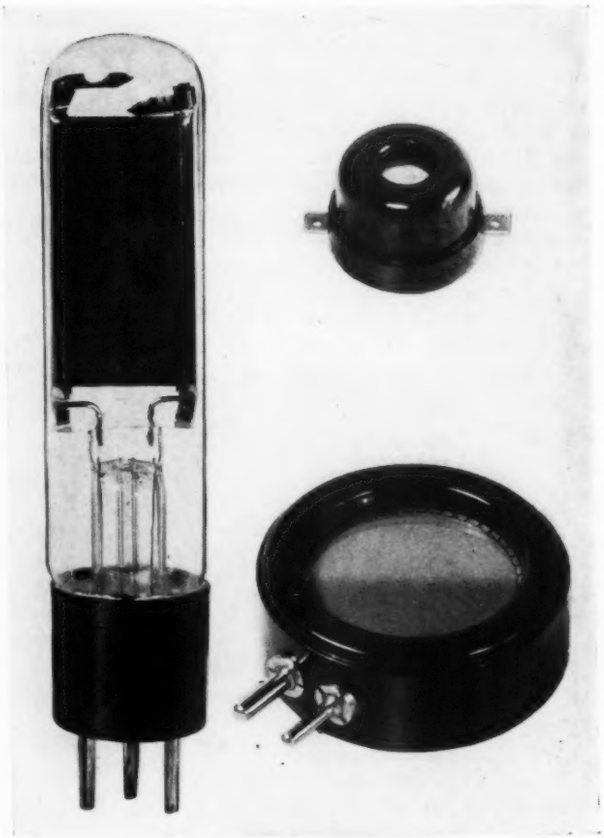


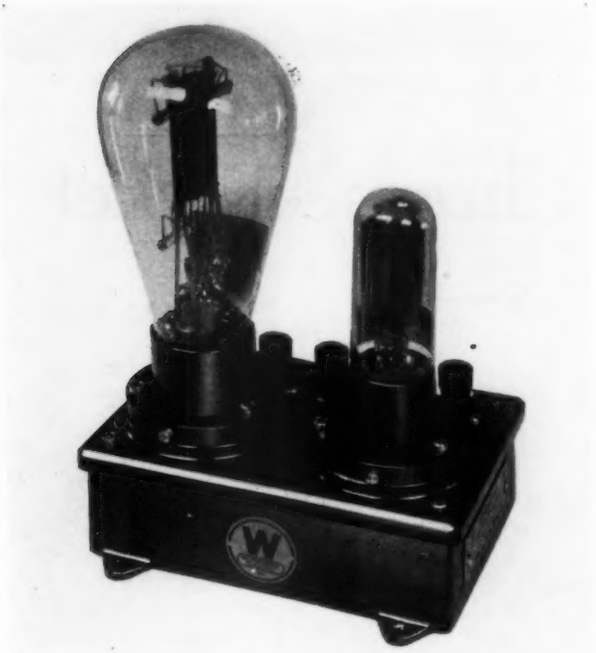
Fig. 2—The photo-voltaic cell (lower right) operates sensitive relays directly. Photo-conductive tubes such as the Burgess selenium cell (left) also operate relays directly or can be used with electronic amplifiers. The small Cico selenium cell (upper right) like the photo tube, requires an electronic amplifier. Illustrations are about two-thirds actual size

The speed of response is well illustrated by the ability of this combination to reproduce sound from moving picture film.

When an a.c. circuit is operated by the grid controlled tube the photocell impulse must be more than one-half cycle long, otherwise the impulse may occur during the period of no current flow in the tube and no operation will result.

Photocells must be protected from severe vibration and temperatures above 110 deg. F. or below 50 deg. F. Precautions are necessary to keep dirt and moisture from the tube contacts, otherwise minute currents may leak across the contacts and seriously affect the operation of the amplifier or rectifier. When the cell is separated from the amplifier, the leads must be provided with generous insulation to prevent leakage of current and capacity effects. Leads longer than three or four feet should be avoided, if possible. In many applications the phototube is mounted behind a window in the case containing the amplifier, or mounted directly upon the amplifier, as illustrated in Fig. 3. A separate weatherproof housing for the phototube connected to the amplifier with a short length of armored cable is shown in Fig. 4.

Fig. 3—The phototube (right) requires an electron tube and amplifier to intensify the low current response characteristic of this tube



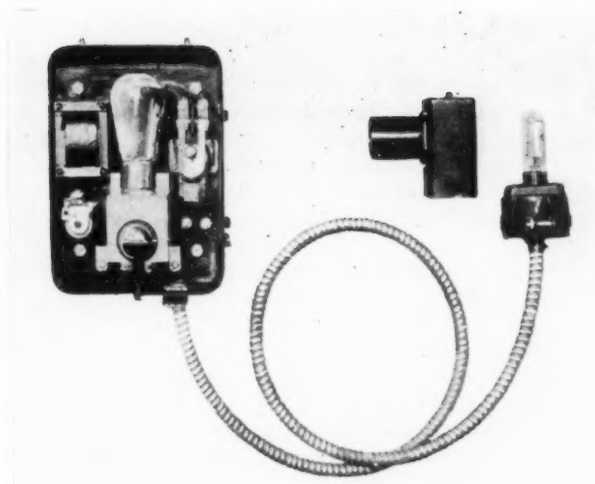


Fig. 4—In this General Electric control unit, the case contains power supply, amplifier and relays, connected to the photo-tube housing with a well insulated, shielded cable

Also adaptable to positive response applications is the photo-conductive or selenium cell, the third and oldest type of light-sensitive cell. In one available form it consists of a glass plate covered with a selenium compound in the form of a network or grid and inclosed in a gas-filled glass tube as illustrated in Fig. 2. Photo-electric effects in selenium cells result from a decrease in electrical resistance when the sensitive plate is illuminated. That is, the dark resistance for different types of cells is from 10 to 50 times as great as the resistance when the cell is exposed to sunlight. When a constant d.c. potential of 100 to 200 volts is placed in series with the selenium cell, the value of the current in this circuit varies through a wide range as the resistance of the sensitive element changes.

When the cell is not illuminated its resistance is several megohms. Even this resistance allows an appreciable flow of current. Because of the appreciable "dark current," the grid controlled rectifier tube can be used only with the higher resistance selenium cells. In the tube type of selenium cell illustrated, the resistance of the light-sensitive element is high enough to allow use of electronic amplifiers, yet the output is sufficient to operate a polarized type of sensitive relay of about 7,000 ohms. In the smaller cell the resistance is about the same as for the photo-emissive cells.

Selenium cells have the advantage of greater power output under restricted illumination, and wider range of adaptability than other cells. Although an external potential is required, one type of selenium cell operates relays directly. The other selenium cell has the same sensitivity as the phototube but occupies much less space, and is better protected from damage.

Variations in the impressed voltage produce variations in the output, and the resistance of the cell is subject to aging. Also, complete response in the selenium cell does not take place as rapidly as in the other types of cells, since it requires an appreciable time to change the resistance. But under high intensity illumination, the initial portion of the response takes place rapidly so that operations at the rate of 1,000 per min. can be obtained using the initial partial response. By this method selenium cells can be adapted to reproduce sound frequencies.

Although the initial step in the adoption of a photo-electric control is to select the most suitable type of cell and amplifying device, in many instances the design of the mechanical devices operated by the photocell impulse is the more difficult problem. In a forthcoming number of *Product Engineering* there will appear a number of examples of mechanical devices designed to perform various types of mechanical operation under control of a photocell.

Equipment for the manufacture of nitric acid, made from 18 per cent chrome iron by the Downington Iron Works

The Chrome and Chrome-Nickel Iron Alloys—II

Corrosion resistance, physical properties and workability of chrome-nickel alloys, including tests for determining the class of alloy most suitable for a given service

T. HOLLAND NELSON, *Consulting Metallurgist, Philadelphia, Pa.*

IN THE first part of this discourse, appearing under the same title in the July *Product Engineering*, the corrosion-resisting iron alloys were divided under four classifications. For convenient reference, the table of classification is repeated here.

Classification of Corrosion-Resistant Iron Alloys

A—Iron with varying percentages of chromium.
B—Iron with varying percentages of nickel.
C—Iron with varying percentages of chromium with nickel present in somewhat smaller proportions than the chromium.
D—Iron with nickel present and chromium also present in smaller proportions than the nickel content.

The three groups of alloys under Class A, containing varying percentages of chromium, were discussed in the above mentioned article. Class B is the straight nickel series. Relatively, these alloys are not used extensively and they will be passed over with the comment that alloys in this class usually contain 3 to 5 per cent nickel, or 36 per cent nickel. The former is used for such applications as turbine blading. The latter is used extensively not only on account of its value as a corrosion-resistant material, but also because of its non-magnetic properties and its unique coefficient of expansion and contraction.

In the accompanying table are given the typical analyses of the three groups of chrome-nickel alloys that fall in Classification C. These alloys are all of the austenitic type and cannot be hardened by quenching. As an example, Group 1 of Class C alloys is typical of the well known 18 and 8 type. It can be obtained in all forms from the casting up to the most intricate finished forms.

The 18 and 8 chrome-nickel alloy began to make definite industrial progress in the United States in about 1927 or 1928. Believing that the embrittlement experiences and the limited working ranges of the straight chromium materials were things of the past and that the 18 and 8 was more or less adaptable to all purposes, over-enthusiasm led to numerous misapplications. Practical experience, however, shortly brought to light the phenomenon known today as carbide precipitation which produces an embrittlement when the material is held at a temperature in the neighborhood of 1,250 deg. F. for an appreciable length of time. Thus, whereas the simple chrome steels had an embrittling range be-

tween 800 and 950 deg. F., the new material produced a similar result but at a higher temperature, namely, approximately 1,250 deg. F.

Carbide Precipitation

It is believed that the accumulation of chromium carbide at the grain boundaries, with the resulting impoverishment of chromium in the metal immediately adjacent to the grain boundary, is responsible for the embrittlement produced when maintaining this material at a temperature in the neighborhood of 1,250 deg. F. for an appreciable length of time. It is also thought that this is the reason why the embrittled material is subject to intergranular acid attack.

During the past years there has been considerable metallurgical progress and today we are in a position, at least to a considerable extent, to prescribe a cure. Briefly stated, the addition of titanium and special treatment substantially prevents the accumulation of chromium carbide at the grain boundaries and the impoverishment of chromium immediately adjacent to the boundaries.

Materials of the Class C—Group 1 type are to be found in widely diversified fields of application, covering particularly food machinery, kitchen equipment, dyeing equipment and for various decorative applications such as radiator shells, headlights and similar automobile parts.

The material in Class C—Group 2 can be obtained in practically all commercial forms. This alloy has a higher content of chromium and nickel and is less susceptible than the 18 and 8 to carbide precipitation, but is not immune to it. The values of the higher alloy content are to be found in the increased corrosion resistance of the material.

Class C—Group 3 is an alloy probably not so well known, but it has come to the front within the last year or so, particularly when dealing with complex acid solutions. Whereas this material offers considerable resistance to sulphuric and hydrochloric acids, it cannot be claimed as commercially resistant to these simple solutions. Nevertheless, in complex working solutions,

Properties of Corrosion-Resistant Iron Alloys Classification C

ANALYSIS

	Group 1	Group 2	Group 3
Carbon	0.05/0.15	0.10/0.50	0.15/0.50
Silicon	0.25/0.75	0.25/0.75	0.25/2.50
Manganese	0.25/0.75	0.25/0.75	0.25/0.75
Sulphur	0.03	0.03	0.03
Phosphorus	0.03	0.03	0.03
Chromium	17/19	23/25	23/25
Nickel	7/9	10/12	19/21
Vanadium	optional	optional	optional
Molybdenum	optional	optional	optional
Tungsten	optional	optional	optional
Titanium	When used to the extent of approximately five to six times the amount of the carbon content, titanium is found to be distinctly advantageous in preventing, or at least retarding, carbide precipitation.		

PHYSICAL PROPERTIES

	Group 1	Group 2	Group 3
Max. stress	85,000/110,000	85,000/125,000	75,000/110,000
Yield point	35,000/50,000	45,000/60,000	40,000/60,000
Elongation per cent in 2 in.	55/35	50/35	35/25
Reduction of area, per cent.	75/55	70/50	50/30
Brinell	140/180	150/200	150/200

Properties of Corrosion-Resistant Iron Alloys Classification D

ANALYSIS

	Group 1	Group 2	Group 3
Carbon	0.10/0.30	0.25/0.50	0.30/0.50
Silicon	0.50/3.00	0.50/3.00	0.50/3.00
Mang nese	normal	normal	normal
Sulphur	0.03	0.03	0.03
Phosphorus	0.03	0.03	0.03
Nickel	18/25	30/40	50/70
Chromium	10/15	15/20	15/25

PHYSICAL PROPERTIES

	Group 1	Group 2*	Group 3*
Max. stress	65,000/90,000	60,000/86,000	60,000/90,000
Yield point	40,000/50,000	35,000/45,000	35,000/55,000
Elongation per cent in 2 in.	35/25	5/40	5/35
Reduction of area, per cent	50/30	5/60	5/50
Brinell	150/200	150/200	150/200
Impact Izod ft.-lbs	35/70	25/75	40/100

*These figures cover cast and wrought materials.

Strength at Elevated Temperatures of Alloys in Classification D

TENSILE STRENGTH

Metal Cr	Metal Ni	Temperature Deg. F. 1,400	1,500	1,600	1,700	1,800	1,900	2,000
25.00	10.00	34,800	23,000	18,350	15,900	11,850	....	....
15.00	35.00	35,500	24,300	19,000	15,200	12,050	9,200	....
20.00	60.00	33,100	24,100	18,200	14,200	11,400	9,600	8,350

Held for 1 hour and pulled at specified temperatures.

SAFE DESIGN STRESS

Metal Cr	Metal Ni	Temperature Deg. F. 1,400	1,500	1,600	1,700	1,800	1,900	2,000
25.00	10.00	4,500	2,700	1,800	1,300	500	....	....
15.00	35.00	4,700	2,900	2,000	1,400	600	300	....
20.00	60.00	4,400	2,800	1,900	1,200	575	320	200

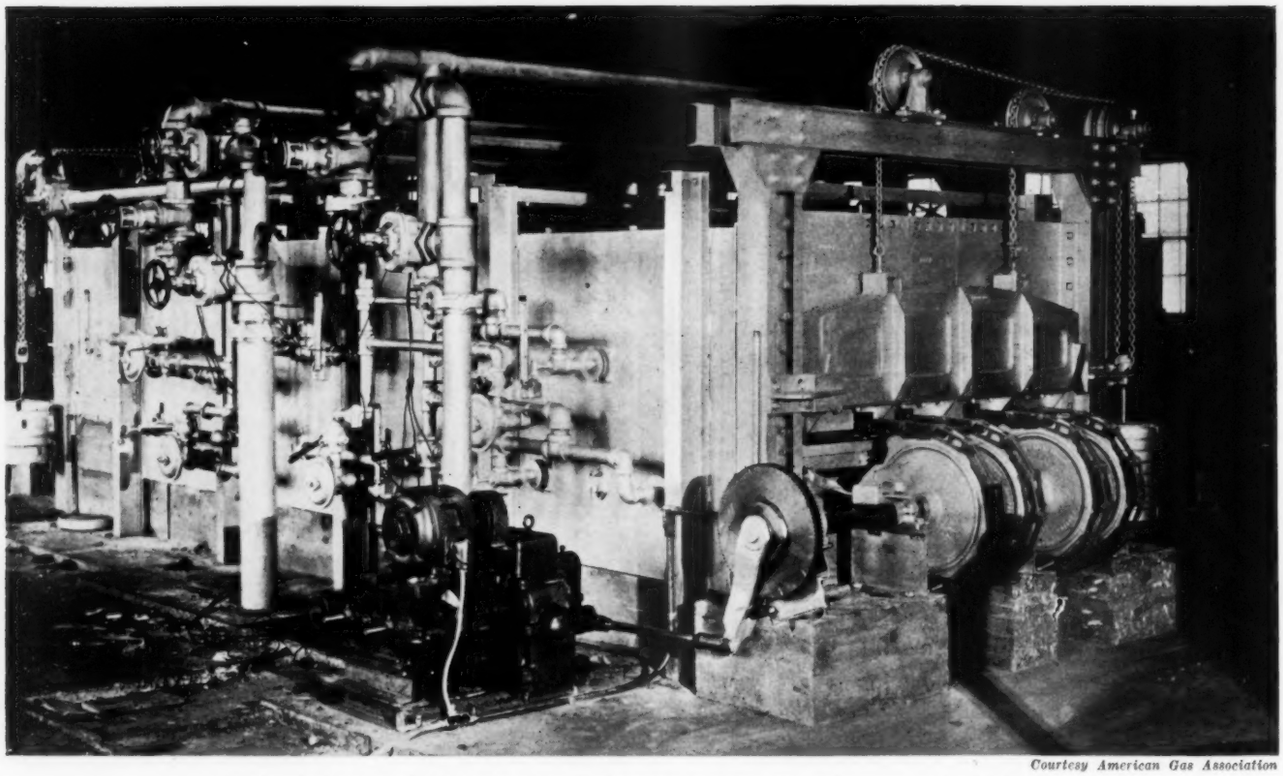
which are so often encountered in the process industries, this alloy has been found to render excellent service. It has the added advantage of being available in practically all forms required.

The tendency of delaying carbide precipitation is even greater for this Class C—Group 3 alloy than in the Class C—Group 2 alloy. Although it cannot be claimed that the Class C—Group 3 alloy is immune to carbide precipitation, it is certainly far less susceptible. Substantial quantities of this material are used in the field of heat resistance for temperatures up to 1,800 to 1,900 deg. F., and where the alloy is suitable for resisting the corrosive action of the by-products of combustion or of specially introduced gaseous atmospheres.

Alloys in Classification D

In the D classification there are quite a few exceptionally good alloys used to resist corrosive liquids and gases in the lower temperature field. But perhaps the greater part of this tonnage is used in the higher temperature fields for the combined purpose of heat resistance as well as the resistance to corrosive atmospheres at elevated temperatures. Typical analyses of materials in Class D are given in the accompanying table.

In the Class D alloys we have another case of overlapping between the fields of corrosion and heat resistance, particularly for those alloys falling in Group 1 of Class D. This last is one of the few materials having a higher nickel than chromium content and which is capable of being pierced and produced in seamless tube form. It is therefore available in practically all forms



Courtesy American Gas Association

Mechanical parts of the feeders for continuous furnaces not only must resist high temperatures but are also subject to mechanical loads, thermal stresses and wide fluctuations in temperature. High chrome-high nickel alloys are used for such service

for use in the field of corrosion as well as various applications calling for use at elevated temperatures.

Generally speaking, when the analysis indicates a material substantially higher in nickel than chromium, such as, for instance, materials in Groups 2 and 3, Class D, difficulty in fabrication is experienced with the result that the forms in which the material is available are considerably restricted.

These materials have been handed down from the field of heat resistance and by virtue of the increasing knowledge of their value in the field of corrosion resistance have been adopted advantageously for many purposes where it has been possible to obtain them in the desired form. The accompanying table gives the results of short time tests on a series of alloys similar to those in this classification.

Special Alloy Additions

A word with regard to special alloy additions. The first stainless steels (so-called) of Brearley and Strauss were simple alloys of iron and chromium and iron, chromium and nickel. Various shortcomings of these alloys and the usual routine of metallurgical research has been responsible for the injection of a variety of other materials into the original combinations, such, for instance, as tungsten, molybdenum, vanadium, titanium, columbium, zirconium sulphide, selenium, high sulphur, and copper with silicon. Wide and various are the claims made for these special elements and time alone will prove their value or otherwise.

It may be stated generally that both molybdenum and tungsten raise the mechanical properties of the materials at elevated temperatures as determined by short time tests, though it may be doubted whether this fact proves true over long time creep tests.

Molybdenum is claimed to improve the corrosion-resistant properties in general. The author has always somewhat doubted this, except where molybdenum as an element shows greater resistance to the particular corrosive solution than iron, in which case it is obvious that the elimination of a certain amount of iron and its replacement with molybdenum would be of value.

Vanadium, titanium and columbium function particularly in the control of carbide precipitation in the chrome-nickel group of alloys, it being generally conceded that up to about 0.20 per cent carbon content, five times the amount of titanium will substantially prevent or retard the formation of chromium carbides at the grain boundaries. Twice this amount of vanadium is usually found necessary to accomplish the same purpose.

A special stabilizing treatment is also recommended in conjunction with these additions to cause the dispersion of such carbides as may be formed in fine particles throughout the crystals. The network at the grain boundaries and the subsequent impoverished pathways which permit local corrosion and intergranular disintegration are thus prevented.

Zirconium sulphide, selenium, copper with silicon, and higher than normal sulphur contents all function in the direction of producing "free machining stock." The author agrees with these claims in general and registers his own particular preference for the copper-

silicon combination on the grounds that both copper and silicon have undoubted corrosion resistant values as well as considerably facilitating machinability. This view, however, should not be construed as detrimental to other claims, it being entirely personal, based upon material the writer has been investigating recently.

Concerning Corrosive Media

Many data have been published with reference to the resistance of various alloys to the three major acids: sulphuric, hydrochloric and nitric. It is therefore interesting to note the effects of the different elements in retarding attack by these particular solutions.

With this object in view I ran a series of experiments which showed that the simple chromium-iron alloys were effectively resistant to nitric acid. Another series of tests showed that in sulphuric and hydrochloric acids, increased chromium content actually represented increased rate of attack while increasing amounts of nickel steadily reduced the rate of attack. The accompanying tables will bring out this point clearly, and it will be observed that in dealing with nitric acid, as the chromium content is increased the resistance is also improved, while nickel can be added so long as the nickel content does not exceed the chromium content.

On the other hand, the tables show that the increase in chromium is extremely detrimental in the presence of sulphuric and hydrochloric acids and that the resistance of the alloy is greatly improved by the addition of nickel, and definitely improved when the nickel substantially exceeds the chromium content.

In reviewing such data as given here, it should by no means be taken for granted that because a certain type of alloy will resist a 10 per cent solution of nitric acid that it will, of necessity, also resist a complex solution containing many other chemicals in addition to nitric acid. Any or all of these substances in a complex solution may act as corrosion accelerators or inhibitors. One striking instance illustrates this point.

From the foregoing data, simple chromium-iron alloys are of no value whatever in resisting sulphuric acid. But a copper leaching solution containing substantial percentages of sulphuric acid in combination with copper, fails to attack aluminum iron. As a matter of fact, there are installations in actual service in the copper industry built of from 16 to 18 per cent chromium-iron alloy handling constantly a sulphuric acid-copper solution without any appreciable signs of attack. The copper acts as an inhibitor, whereas from generally published data one might be justified in assuming that a simple chromium-iron alloy would be of no use whatever in handling a sulphuric acid solution.

Some little while ago, realizing the difficulties of approaching this and many other industries, I conceived the idea of using definite "indicators" for the purpose of determining the most suitable material for the purpose without having any knowledge of the actual composition of the corrosive solution.

Four indicators are used, corresponding to the four major classifications of corrosion-resisting alloys as given here. These indicators are tested in the actual working solutions and their loss or gain in weight is carefully observed. From these tests, the class of alloy best suited for the purpose is clearly indicated and with a few further experiments the most suitable alloy composition is determined.

Forging and Rolling

Because 12 to 14 per cent chromium stainless steels, even with extremely low carbon content, are all subject to air hardening, the hot working of this material is usually confined to the range of approximately 2,000 down to 1,650 deg. F. After such hot working, the material will air harden and it is advisable to anneal.

If the chromium content is in excess of 16 per cent, referred to in this text as the non-hardening type, the alloy should be worked down from temperatures of approximately 2,000 deg. F. to a temperature in the neighborhood of 1,400 deg. F. or even lower. On cooling, the material will not air harden, but will have higher mechanical properties in the rolled bar than it will have if it is later subjected to a temperature of 1,400 deg. F. and air cooled. Usually material of this type in the as-rolled condition will have a tensile strength of approximately 90,000 to 100,000 lb. per sq.in. After a treatment at approximately 1,450 deg. F., the tensile strength will fall to approximately 75,000 lb. per sq.in., and subsequent heat-treatment will in no way increase this.

Chrome-nickel alloys containing 18 per cent chromium and 8 per cent nickel should be hot worked from a temperature of approximately 2,100 deg. F. down to about 1,500 deg. F. Before further work or operations are done on the material, it is advisable to either air quench or water quench from 1,900 deg. to 2,000 deg. F.

Fabrication

The lower chromium alloys, 12 to 14 per cent chromium, are not used to any great extent in large fabricated structures because they are air hardening. However, where such material is insisted upon or specified, a full anneal is required to obtain maximum ductility. As a full anneal places this material in its least

Effect of Chromium and Nickel Content on Corrosion Resistance

5 PER CENT SULPHURIC ACID AT 110 DEG. F.				5 PER CENT HYDROCHLORIC ACID AT 110 DEG. F.				5 PER CENT NITRIC ACID AT 110 DEG. F.			
Chromium Per cent	Nickel Per cent	Iron Per cent	Loss mg/cm²/hr.	Chromium Per cent	Nickel Per cent	Iron Per cent	Loss mg/cm²/hr.	Chromium Per cent	Nickel Per cent	Iron Per cent	Loss mg/cm²/hr.
24.10	nil	74.91	28,500	24.10	nil	74.91	27.425	24.10	nil	74.91	0.333
33.83	nil	65.29	43,400	33.83	nil	65.29	54.360	33.83	nil	65.29	0.056
43.26	nil	55.75	40,260	43.26	nil	55.75	101.800	43.26	nil	55.75	0.073
18.28	10.10	70.79	0.686	18.28	10.10	70.79	0.775	18.28	10.10	70.79	0.029
24.36	10.30	64.41	0.854	24.26	10.30	64.41	11.180	24.26	10.30	64.41	nil
10.40	24.40	64.01	0.078	10.40	24.40	64.01	0.310	10.40	24.40	64.01	5.930
24.15	19.20	55.74	0.177	24.15	19.20	55.74	0.717	24.15	19.20	55.74	0.019

It is shown in the above tables that the rate of attack of 5 per cent sulphuric and 5 per cent hydrochloric acid solution increases with the chromium content whereas the effect of nickel is to retard solubility. Therefore it is safe to assume that the best alloy for these tests will be one in which nickel predominates. In the test with 5 per cent nitric acid as tabulated above, it is shown clearly that for solutions of this type chromium should predominate.

corrosion-resistant condition, it is not surprising to find that little of the 12 to 14 per cent chromium is used in chemical installations.

Extensive use is made of the 16 to 18 per cent chromium alloy for fabricated structures for chemical purposes. Being non-air hardening it can be handled without great difficulty. The material as delivered to the fabricator usually has been annealed at 1,450 deg. F. If it is necessary to heat the material for the purpose of local fabrication, driving rivets, flanging or dishing, the temperature used should never be in excess of 1,450 deg. F. and preferably between 1,200 and 1,400 deg. F., within which temperature range the 16 to 18 per cent chromium alloy works readily, can be deformed easily, will have no tendency to harden and will not undergo crystalline growth. If, on the other hand, higher temperatures are used the straight chromium irons readily develop large crystalline structures and become correspondingly mechanically weak.

As distinguished from the straight chromium alloys the 18 and 8 stainless materials require almost the opposite in heat-treatment. A temperature below 1,250 deg. F. for hot-working is disastrous to this type of material. It is essential that all hot-working operations on 18 and 8 should be carried out in the elevated ranges. If considerable work is done on this material through a falling temperature range, the minimum temperature should never be less than 1,500 deg. F. For the best condition to resist corrosion, the material should be heated again to approximately 1,900 to 2,000 deg. F. and cooled as rapidly as possible.

It should be emphasized that the success of the heat-treatment is entirely dependent upon the rapidity of cooling. Heating to 2,000 deg. F. and cooling slowly might possibly create more trouble than no heat-treatment at all. Local application of heat to produce unusual deformation should always be followed by heat-treatment and rapid quench in the neighborhood of 1,900 to 2,000 deg. F.

Rivets of 18 and 8 should be driven as rapidly as possible at approximately 2,100 deg. F. Usually they are quenched effectively and rapidly by the adjacent cold material into which they are driven.

It is obvious that the higher mechanical properties call for increased power and perhaps an increase in the number of operations for shearing, forming and bending as compared to mild steel. Wear on the tools, particularly shear blades, will be a more serious problem and the wear from abrasion on forming dies is increased to some extent. In bending rolls, for cold bending, it is usually found only necessary to increase the number of passes to obtain the same result, although in the 18 and 8 type of materials, which have a tendency to work harden, heat-treatment between passes for the purpose of strain release is often found necessary.

The higher alloys wherein nickel substantially predominates chromium are invariably austenitic in practically all conditions, but should always be air or water quenched from a temperature of approximately 1,900 deg. F. at least.

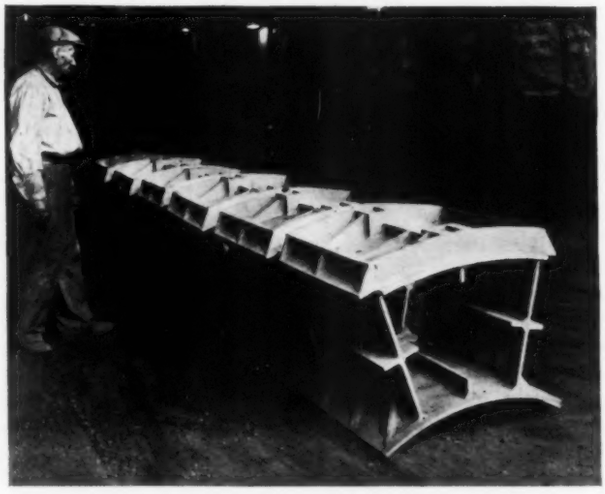
Impact Values

The straight stainless steels, 12 to 14 per cent chromium, can be heat-treated to give impact values up to the capacity of either the Izod or Charpy machine. But the 16 to 18 per cent chromium steels, with elongations and reductions of area running higher than the 12 to 14 per cent chromium steels, may be found to have quite a poor impact value, which ranges from approximately 5 to 25 ft.-lb. On the other hand, the 18 and 8 type can be so prepared as to give an impact value quite beyond the capacity of the Izod machine which registers 120 ft.-lb. maximum.

Carbon Content

Much discussion and a great deal of advertising data surrounds the debatable point of carbon content. We have today many instances of specifications calling for 0.07 carbon maximum, and these specifications are broadcast to cover the requirements of installations involving the use of everything from castings to finished wrought material. I have always felt that in this direction we are probably suffering to some extent from an overdose of idealism and that frequently the parties issuing the specifications are not as capable as they should be of visualizing the various manufacturing problems involved.

As a typical instance, it is possible to produce 18 and 8 chrome nickel alloy with 0.07 carbon and there are probably occasions where it is essential to use this material. But there are many more applications where an



Heat-resisting chrome-nickel castings used in a cement kiln where they are subject to temperatures between 1,800 and 2,000 deg. F.

adjustment of the chrome and nickel ratio, that is to say, an increase of both chrome and nickel, will allow the use of carbon contents up to 0.25 per cent. This makes it possible for a foundry to turn out castings much more economically, and from the author's general experience the higher carbon content gives sounder castings. The extremely low carbon analyses are typical of specifications that should be confined to wrought materials such as bars, sheets, plates and rivets.

One final word in this direction. I would not wish it understood that I believe that carbon content can be ignored. On the other hand, I do not think that there is any doubt whatever that the carbon content can be adjusted with safety in a ratio to suit both the chromium and nickel content.

Colored Plastics

F. E. BRILL
General Plastics, Inc.

UNFORTUNATELY for one who would specify colored molded parts, the various materials have limited fields of application. There are hundreds of queer names and claims represented, out of which one or two are possible choices.

Two major groups of plastics present themselves: thermo-setting and thermo-plastic. The first sets permanently in the hot mold; the latter will again soften under heat after molding. It is the first group that has the widest industrial application.

The thermo-plastics include glyptols, cellulose acetates, vinyls, and rubber-base resins, all having applications for novelty ware, *objets d'art*, and similar products. But they are unsuitable for industrial precision molding because of their higher cost, instability under heat and other deteriorating influences. Also, there are unclassified thermo-plastics; cold-molded material, asphalt and shellac base, available only in dark colors and used for electrical parts where low cost and heat resistance are more important than finish and strength; and hard rubber, having some of the attributes of cold-molded pieces, but superior in structure and surface finish.

In the thermo-setting group are the phenolics, (Durez, Bakelite, etc.) and the ureas, (Beetle, Plaskon, Unyte, etc.). The phenolic is more widely used.

The light color of the base resins of the urea type make possible pure white and pastels with a depth of finish and translucency, which fits them for such applications as kitchenware and novelties. The ureas are less suited to industrial molding because they cost more, are limited to thin cross-sections, are not as moisture or chemical resistant, do not take molded-in inserts as well, and do not lend themselves as well to precision molding.

Phenolics

Although they have wider application, phenolic materials are more limited in color range because the natural color of the phenol resin is amber. This precludes the possibility of a pure white compound but permits pigmentation to any other desired color.

All plastic materials discolor somewhat over a period of time. But recent improvements in dyes and in the resins themselves have reduced considerably the amount of discoloration on exposure to sunlight. The blues, greens, ivories and other pastels fade more quickly than reds, browns, maroons, magentas, and buffs. Despite this fading tendency millions of pounds of colored phenolic compounds have been used.

Where the shape of the piece and its function preclude the use of urea plastics, and color is desired, the designer should specify one of the darker phenolic colors, or a color of red derivation, such as brown, tan or maroon, especially if the part is to be exposed to direct sunlight, as in a fan, thermometer or typewriter.

Another method of minimizing discoloration is to use "grayed-out" or "indefinite" colors, such as blue-green, gray-green, gray-blue, and the diluted reds. One of America's best-known industrial artists uses and advocates this method, claiming that it blends the object more easily into room-furnishings since brilliantly or garishly colored molded objects often clash with other decorations. Then, too, women prefer these less garish tones, and it is also assurance that the colors will blend well with each other, for dilution with "neighboring" colors automatically prevents clashes.

Standard Colors

Most of the compound manufacturers have a "standard" swatch or assortment of color chips which is distributed to designers and others specifying molded parts. The colors on these swatches can be obtained from stock at the manufacturer's plant, whereas special colors must be run to order. Since matching and pigmentation is done specially for each color-variation, special colors cost more, unless the volume involves thousands of pounds.

Combination of colors in one molded piece is possible but not practical for high production work, although it has been especially well done, with sharp lines of demarcation, by the extrusion molding process. Simpler methods of getting multi-color effects are combinations, where possible, of two or more separately molded pieces of different colors. Mottled or striated effects have been used in the past, and require only the mixing of different-colored powders.

Special Compounds

Quite often, the mechanical requirements of the molded piece will require specific materials and thus limit the use of color. For example, extra-strength materials, necessary for telephone handles and the like, are available only in black and natural phenolic. Heat-resistant materials, often necessary for toaster-bases, percolator handles, and utensil knobs, come only in black and browns. High dielectric materials likewise are limited in the colors available.

Since a majority of household appliances and other mechanical devices find black and brown their most logical colors, the designer cannot resort to color to carry the burden, and it takes intelligent planning to get proper contrast with the black molded parts. Metal accents or metal fuctional parts can be used to advantage to get the proper value contrasts. Industrial artists Teague, Sinel, Streng and others, demonstrated the richness of metal-and-black-plastics and engraved plastics alone, in the Taylor Humidiguide, the Acousticon and the Colonial Compact Radio respectively.

On the other hand, some of these special materials necessary for certain applications come in a wide color-range. For instance, General Plastics' recently announced water-, acid- and alkali-resistant material. This compound, developed especially for chemical containers, was later aimed at the cosmetic jar market.

Shifting Mechanisms

Typical linkages for the axial movement of

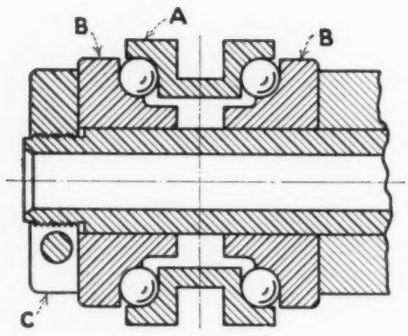


FIG. 1

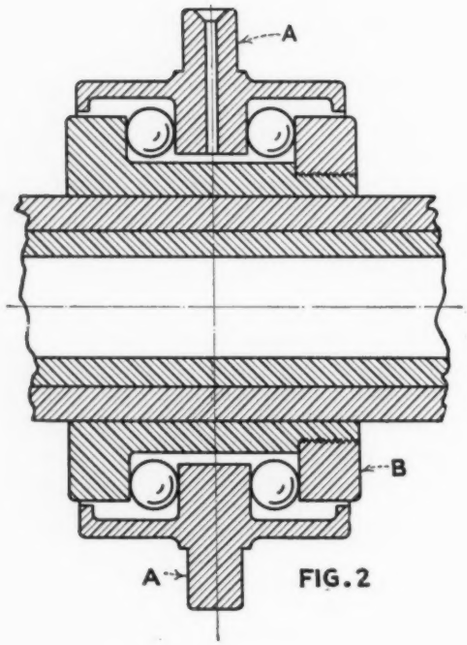


FIG. 2

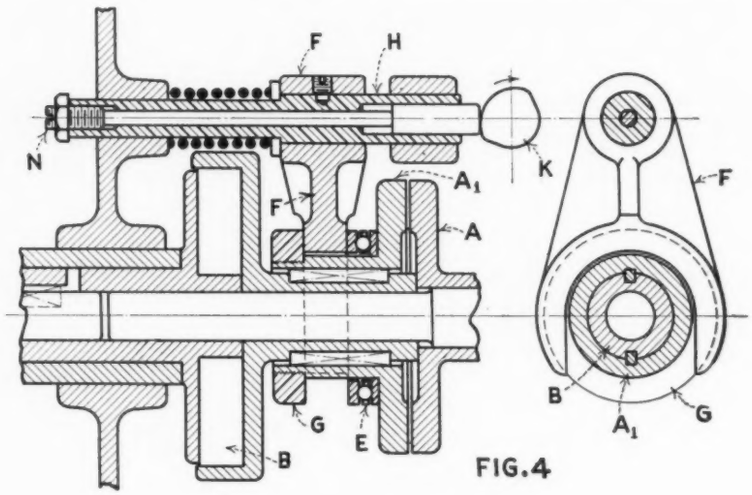


FIG. 4

ADAM FREDERICKS

Fig. 1—Clutch shifting spool *A* is mounted on balls seating in collars *B-B*. No ball separators are used. Nut *C* adjusts end play.

Fig. 2—Shifting collar with trunnions *A-A* is mounted on two rows of balls, the assembly being held together by the adjustable nut *B*.

Fig. 3—Eccentric crank *A*, integral with shaft *B*, actuates bronze rectangular shoe *C*. Positioning is by drilled spots engaging the spring-backed plunger in handle *D* which is peened over in the shifting lever *E*.

Fig. 4—Overrunning clutch *B* drives A_1 which is controlled by shifting yoke *F* mounted on shaft *H* actuated by cam *K*. Thrust bearing *E* and adjusting nut *G* position the shifting yoke. Screw *N* adjusts clearance between clutch disks.

Fig. 5—Rack teeth in hub *A* of shifting fork *B* engage gear segment *C*, to which is attached shifting lever. Fork *B* slides on fixed rod *D*.

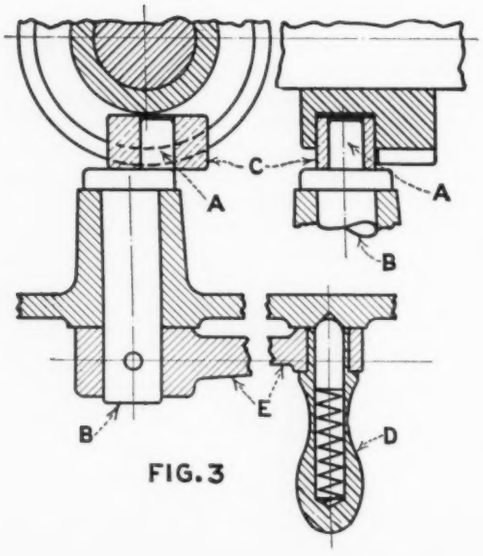


FIG. 3

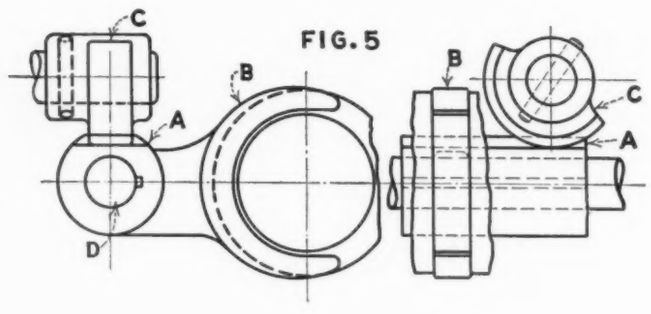


FIG. 5

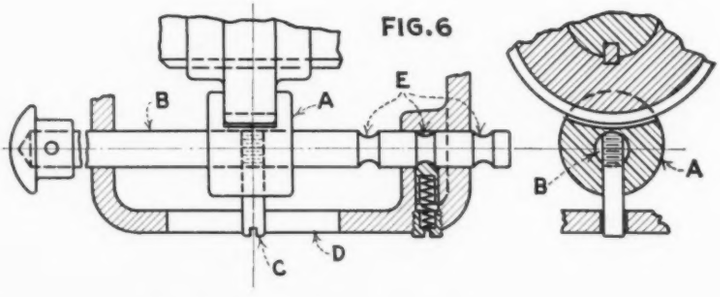


FIG. 6

for Gears and Clutches—I

gears, clutches, wheels or other machine members

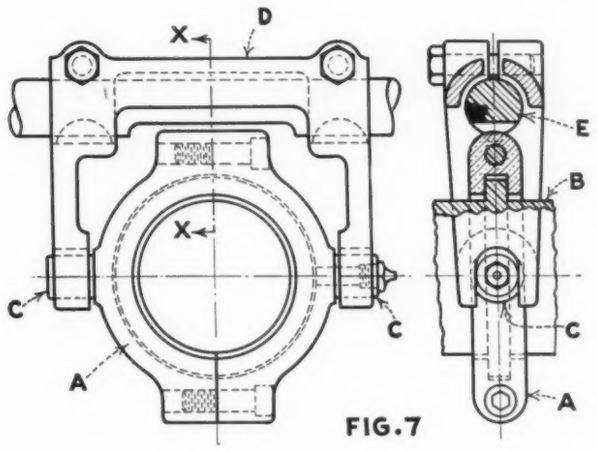


FIG. 7

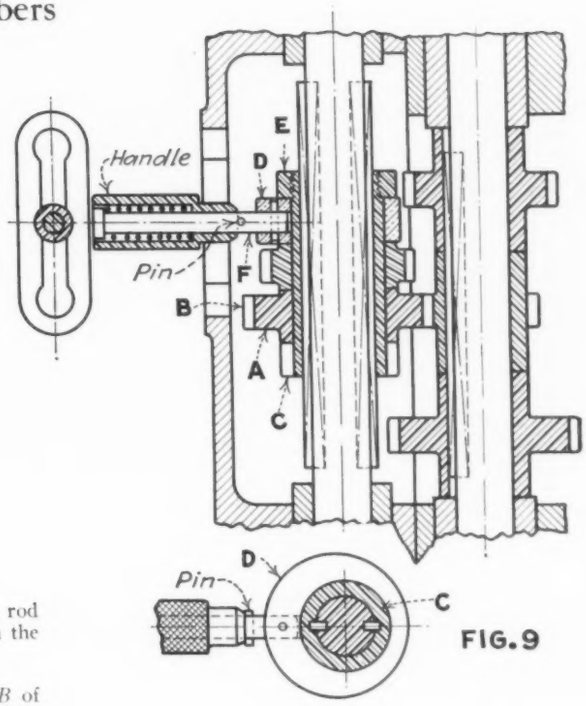


FIG. 9

Fig. 6—The gear is moved by the fork *A* which is fastened to shifting rod *B* by screw *C*. Latter is guided by slot *D*. Turned grooves *E* position the rod by engaging the spring plunger.

Fig. 7—Two-piece bronze clutch yoke *A* engages the flanged member *B* of clutch. Finished trunnions *C* engage malleable iron shifting fork *D*. The shaft *E* on which the yoke is mounted is cut away for clearance. The yoke is split and held clamped on the shaft by two capscrews.

Fig. 8—Bell-crank shifting fork *A* has two steel rectangular shoes *B* mounted on inserted pins *C*. A wide shoe permits the shifting center *D*, about which the shifting fork rotates, to be brought close to the center of the clutch. *F* is the driving member. Driven members run freely on bushings. The clutch spool is the driving member.

Fig. 9—The three gears and eccentrically turned bronze shifting collar *D* are held together by the adjusting nut *E*. Shifting stud *F* is pinned to collar *D*. The spring mounted handle can be slid along the slot to take any one of the three positions.

Fig. 10—Simple two-piece shifting yoke, the yoke engaging a groove *A* in the clutch *B*.

Fig. 11—Upper surface of shifting bar *A* has teeth milled in to engage the operating pinion *B*, the bar *A* sliding on stationary shaft *C*. No guiding key is required as any angular motion of the gears and rack backlash will not cause interference between the fork and gear.

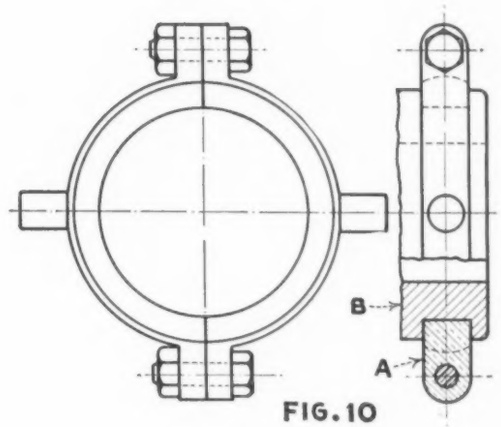


FIG. 10

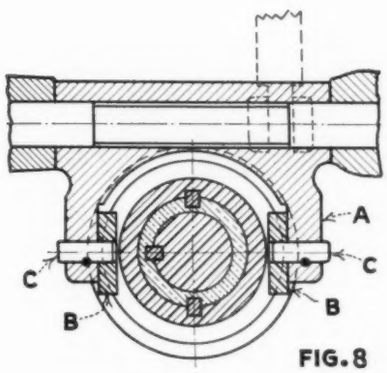
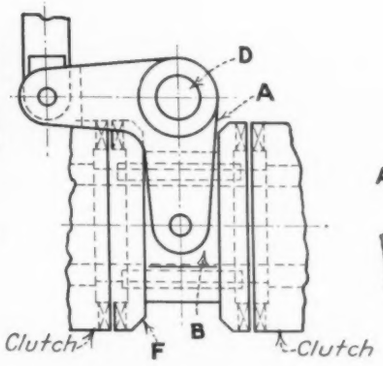


FIG. 8



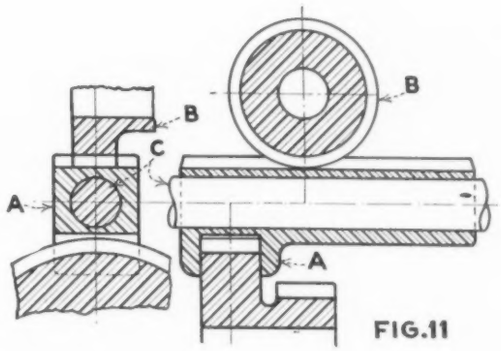


FIG. 11

What Price Quality?

Quality in the ultimate product is not necessarily dependent on the use of the most expensive materials. The author gives ten striking examples where the substitution of less expensive materials resulted in lower costs with equal or better quality

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Westinghouse Electric & Manufacturing Company

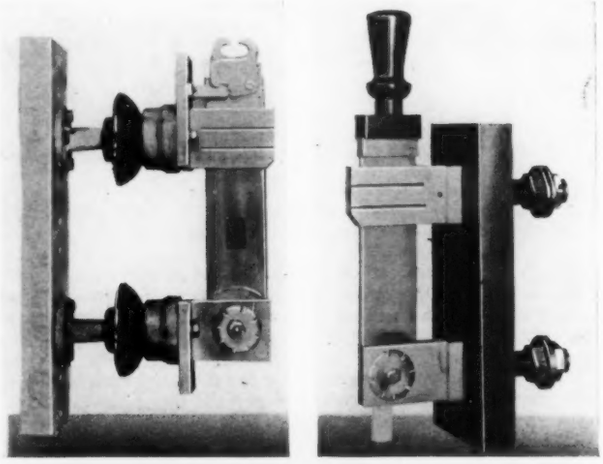
WE OFTEN hear trite statements, axioms or proverbs that we glibly repeat and through constant reiteration come to believe thoroughly. On careful thought many of these can be shown to be fallacious. We have often heard that "The best is none too good," or "You get what you pay for." If we concede that the definition of "best" involves highest quality, inseparably coupled with highest price, considerable doubt can be thrown on the validity of these statements. It is the purpose of this presentation to show that a more serviceable article, a really higher quality device, can often be fabricated from materials that are not the "best" obtainable when judged on a price basis. In other words, "better and cheaper" is a frequent possibility, even though seemingly paradoxical. A careful study will usually show that in many instances we have been wasteful in making use of materials costing more than necessary because needlessly high qualities or finishes had been specified.

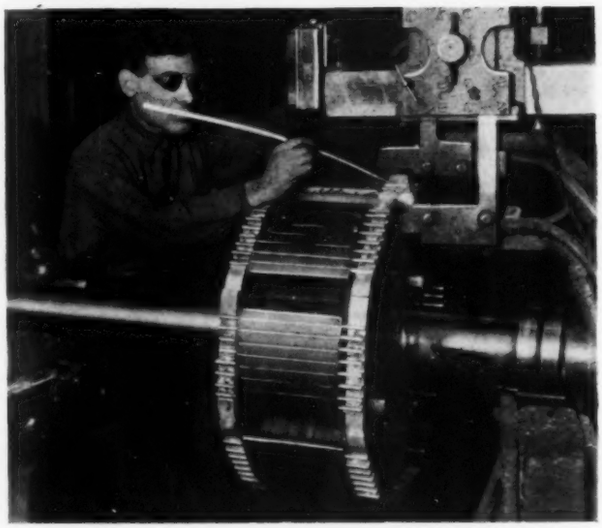
Quality is recognized as an important factor in the marketing of goods to discriminating customers. We have become quality-conscious. Appeal is often made on a quality basis as justification for unfavorable price differences. The ultimate in this attribute, however, is not always required. Various scales of quality are needed to suit a range of applications.

In the automobile business the acme of quality is taken by many to be the Rolls Royce. Undoubtedly it is a better automobile than most of us buy. But it is also true that it is too good for most of us, in that we do not need that quality to satisfy our requirements. Our requirements usually include a limitation on price and a feeling that in a few years we will want a new automobile with all the new improvements. Hence we do not care if the car we buy today does wear out relatively soon.

The same argument of obsolescence and the desire for change applies to clothing. If a device or product is to be used either temporarily or infrequently it is often better practice to avoid the best grades of materials, because the cost of the service rendered would be too high.

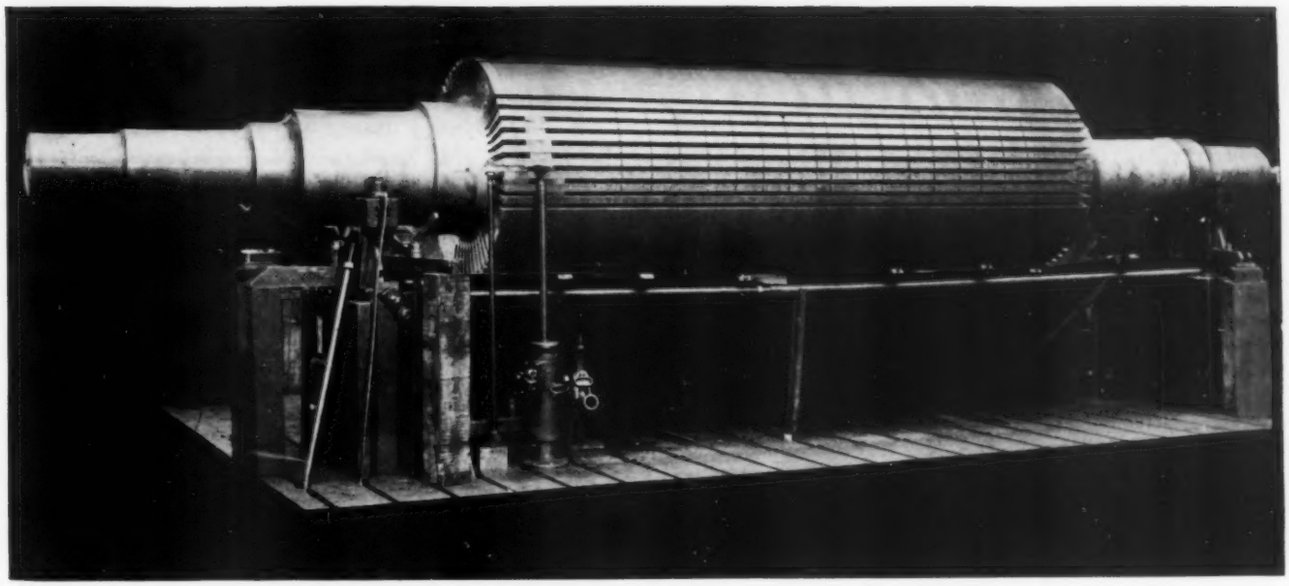
This principle has been observed in making foundry patterns and fabricating tools. If one or a few parts are to be made there is no use in making patterns or tools that will last for several thousand parts. Some-





(Above) For knife switches in a prominent location, appearance counts, and the best grade of finished copper bar is used, while for outdoor disconnecting switches appearance is not an important factor

(Below) A special grade of bronze is required for damper bars in certain synchronous motors. Although expensive, it is worth the extra cost



On large heavy parts such as this rotor, unnecessarily expensive material because of needlessly high quality results in greatly increased costs

times the use of high quality materials or parts does not add to serviceability in proportion to cost. Unless there exists some other reason such as beauty or sentimental value, a waste of money and effort has occurred. For example, a watch costing $500 will offer little better service as a useful timepiece than a $50 watch. For people desiring good timekeeping and a moderate amount of beauty there would be no sense in buying the $500 watch. Although this is perfectly obvious, there are instances in industry where unnecessary emphasis is placed on quality materials. If quality is measured by serviceability, endurance or value received, we find that present practice can often be modified to give the desired result at a lower cost. We should not persist in gold-plating a pick and shovel.

The natural inclination of the designer is to want and use the best he can get. The strongest steel, the highest grade insulation, the purest copper are of advantage in making his job easier. He can better meet guarantees and performance with perfect materials. In the shop the workman also wants the best. Because the best materials machine more uniformly, there are fewer defective pieces, and the appearance of the completed job is a continuing satisfaction to the workman. The urge to use the least expensive satisfactory materials will not usually come from these sources. It must come from those connected with the engineering problems of materials, from the cost reduction organization. In small organizations the responsibility is solely that of the chief engineer. A proper balance between the forces insisting on unnecessarily high cost materials and those trying to beat down the factory cost of products will result in the best use of materials and a careful selection of proper grades.

Illustrating the need and value of careful selection of materials, the following examples have been taken from recent experiences in electrical manufacturing. Some of the changes made indicated errors in judgment in the previous practice, but most of the examples show how a definitely organized and continuous study of new materials will lead to profitable substitutions at no sacrifice of quality. In fact, an improvement frequently results.

Stretcher-leveled sheet steel, a grade which is particularly smooth and flat and is used for switch panels, housings for switchgear and similar applications where appearance is important, can be obtained "re-squared." That is, the sheets have an extra operation after stretching, trimming them to true rectangles of exact size. This saves the user operations in fabrication. Of course, this costs money, about five per cent extra. It was found that a practice had grown up of using this especially fine sheet for smaller parts. Small boxes were being made which required the cutting of the original sheets into small pieces, entirely losing any value that the square original edges may have had. The stretcher-leveled material without re-squaring was adequate.

Just as finished mahogany for patterns would not be used for concrete forms in building a sewer, there are many occasions when finished materials, costing extra, add nothing to the performance, and the improved appearance is of no value. For some electrical apparatus, copper bar with an extremely fine finish is required. The more usual applications, however, can just as well use commercial or market grade copper which has an ordinary smooth surface. Investigation showed that the highly finished grade was being used for a line of heavy switches where the extra quality surface was entirely unnecessary. In one plant, substitution of the market grade of bar copper resulted in a saving of $7,300 in one year.

A special grade of bronze bar having close tolerance on electrical resistivity is required for the damper bars in certain synchronous motors. This special bronze costs six cents a pound more than an equivalent composition without the electrical requirements. It was found that this special bar was being used for studs and

shoulder pins where only mechanical support of some parts was needed. This is analogous to using an expensive tool steel to make a crowbar. It would work but it is a waste of money.

Cotton tape can be obtained with widely different constructions, few heavy threads per inch, many fine threads, different threads lengthwise than crosswise, and various other styles. These tapes are widely used in wrapping electrical coils and are usually impregnated with varnish or other materials. The tape holds the coil mechanically and serves as a carrier for the sealing varnish. A change in one class of tape was made to use a coarser weave which worked fully as well as the finer tape used previously. This saved $12,000 in one year.

For small coils used in instruments and relays, where appearance is important and space is limited, silk tape has always been considered necessary. Silk tape is strong, thin and takes a good finish, but it is expensive. After insistent demand, suppliers have developed a cotton tape which is just as thin, is good in appearance because of a mercerizing treatment, and can be bought for about 40 per cent of the cost of silk tape.

At one time certain types of radio loud speakers were using large quantities of leather as a flexible support for a vibrating cone. A suitable fabric substitute was found which saved $40,000 in a year for one manufacturer.

We would not be satisfied to use unbleached cotton cloth for our best bed linen, but the bleaching adds only to the appearance. In fact, it subtracts somewhat from the strength of the cloth. It was found that it was not necessary even for appearance to use bleached cloth in the manufacture of varnish coated cloth which is used as insulation and is popularly known as "varnished cambric" or "empire cloth." The cloth takes on the color of the varnish used. The use of standard grades of unbleached material resulted in a large reduction in the material cost, inasmuch as there is a fifteen per cent difference in price between bleached and unbleached goods.

On first thought, paper might appear to be inferior to cotton, and it might be for clothing. We have witnessed, however, a trend from cotton yarn to paper for covering copper wires and conductors. This first started on large wires and bars and has proceeded down in size so that thin paper coverings on small wires are coming into use. Here is a good example of the paradoxical combination of better and cheaper. Paper insulation on wire takes up less space, is better insulation when impregnated, and costs less. Its use will be further extended as rapidly as machinery for its manufacture and application is perfected.

With the rapid development of alloy steels and the exploitation of their excellent properties, we have lost sight of the virtues of their "country cousin," the old reliable plain carbon steel. Improvements in heat-treating practice have made it possible to use the lower cost carbon steel for highly stressed rotating machine forgings where it was once thought only the fancy alloys would do. In one shop in a period of four months $56,000 was saved by using the rejuvenated carbon steel forgings for heavy machines.

Virgin timber and virgin metals are supposed to exhibit best qualities. It is well known, however, that second growth hickory is best for making strong, tough wooden sticks to be used as handles or strain members. "Second growth" or remelted non-ferrous metals are also very useful. The various common aluminum alloys can be obtained in the market, remelted from scrap and cast into ingots of guaranteed analysis. For most casting and molding purposes they exhibit physical properties as good as the new metal and are obtainable at a substantial price reduction. In one limited line of products, one foundry saved $45,000 the first year the substitution was made.

These examples show how cost of materials can be reduced through knowledge of their characteristics and an application of improvements as they become available. It is evident that quality in the ultimate product is not necessarily dependent on the use of the most expensive materials. Careful study and selection will usually result in greatly lowered cost.

Material cost is now a major item. In many products the drive for reduction of labor through machine operations has diminished the labor cost to an approximate minimum. To be definite, it can be stated that for all kinds of electrical manufacturing material costs will vary from $1\frac{1}{4}$ to 8 times the labor cost, the average being about $2\frac{1}{2}$. Therefore, the opportunity to save money through reduced cost of materials is many times greater than that of reducing labor costs, keeping in mind that maintenance of or improvement in quality is a first consideration.

One reason for high costs is the natural tendency of engineers to want special materials. Something with exactly the right properties or dimensions would fit the design so splendidly. The result is a small stock of special material at a higher price. Inevitably, and usually soon, since the material is available it gets into wider and wider use. An initial effort to use a standard product or size would avoid this difficulty.

To return to the popular axiom then, we have always been told that "You cannot make a silk purse out of a sow's ear." Perhaps not, but a good pig-skin purse might be more serviceable at less cost.

Black cotton tape fills all the requirements for wrapping the coils and is considerably cheaper than the silk that was used formerly

Graphical Determination of Shaft Deflections

Beginning with the loading diagram, the lateral deflection of the shaft is obtained graphically in five steps. From the maximum deflection thus obtained, the critical speed is calculated directly

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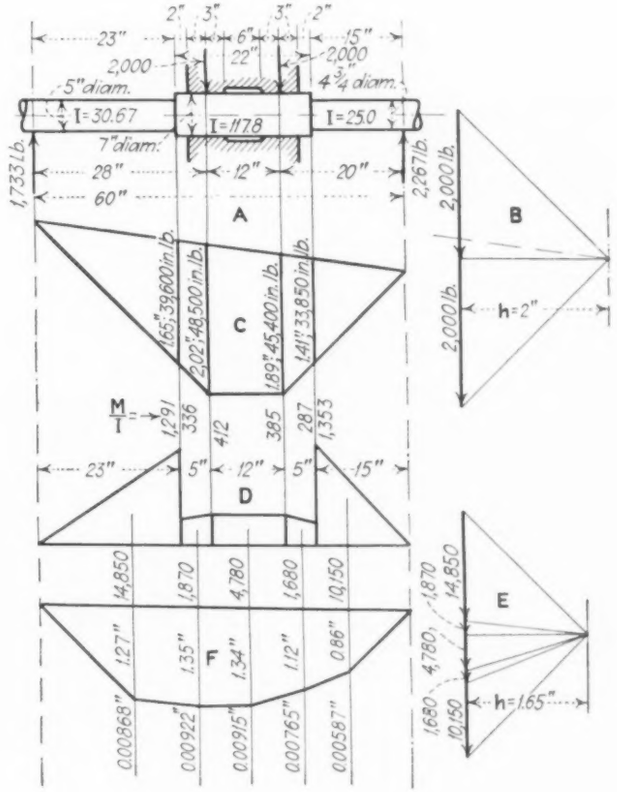
WITH modern high-speed machinery the deflection of a shaft, rather than its torsional strength, becomes of greater and greater importance. It is no longer permissible to determine shaft diameters by simply multiplying the cube root of the horsepower transmitted by a constant and dividing this result by the r.p.m. Unfortunately, the calculations required to determine shaft deflections are extremely laborious and time-consuming, and this factor has largely influenced the continued use of strength calculations by means of empirical formulas for shafts which should be designed for deflection.

Various simplified methods have appeared from time to time for the design of shafts for axial deflection. The following graphical method, used by the writer for a number of years, has the merit of both simplicity and time economy. The general principles set forth here were probable given first by Professor Greene and later considerably elaborated by Morley and others.

To illustrate this graphical method, the design of a generator shaft carrying two loads of 2,000 lb. each, as shown in the accompanying figure, will be carried through. It will be noticed that in the design of this generator shaft the hub of the armature is cored out. The writer follows the practice of coring out the hub as shown, in order to give greater certainty as to the location of the points of load concentration. Whenever long hubs are mounted on shafts with a close fit the entire length of the hub, there is always a great question as to the point of application of the load. It is a matter of much dispute whether or not the actual load concentrations do not really come at the ends of the hub. It is there that the bending really occurs, especially if the hub is sufficiently stiff to resist bending. This is usually the situation to a more or less extent since the diameters are substantially increased and the moment of inertia varies with the fourth power of the diameter. Therefore, there is some error in the direction of safety, in taking the load concentration at points further into the hub. Another element of safety lies in the assumption of shouldered shafts, as in a proper design such shoulders are usually provided either with generous fillets or tapers.

The use of graphical methods avoids the possibility of computation errors because if errors are made, they show up at once in a scale diagram. Besides, the final design should proceed from orderly calculations based on scale diagrams, and the sequence stays better in the computer's mind; if called away, the graphic method



Showing the successive steps in the graphical determination of shaft deflections. *A* indicates the loading, *C* is the bending moment diagram, and at *D* is the *M/I* diagram. The polygon *E* is the *M/I* diagram laid off vertically, and at *F* is the deflection diagram

SEPTEMBER NUMBER

In photo-electric control the major problem is to devise the electrically operated mechanisms that will cause the synchronized electrical impulses to accomplish the desired results with the power available. Various mechanical principles used to solve such problems will be described in the September number

shows just where the work was dropped.

After drawing the shaft and locating the points of application of the loads and reactions, the force polygon B is drawn in the usual manner. A scale of 1,000 lb. per in. was used in this problem. It is preferable to keep the angle of the tapering sides 45 deg. or more to get a larger ordinate in the bending moment diagram.

Start the bending moment diagram C from the left, paralleling the lines in B. The closing line of this diagram, shifted parallel over to B on its pole, is shown dotted and dashed, and gives the left and right reactions to scale. Using a ruler graduated in 50ths of an inch, measure the ordinates of the bending moment diagram C to the nearest hundredth and note them on the ordinates at load centers and diameter changes. To get actual bending moments a multiplier is used whose value depends on the scales used. In the original drawing, the linear dimensions were drawn to a scale of 12 in. to 1 in. As the vertical load scale in B was 1,000 lb. per in., and the pole height, h, was 2 in., the multiplier or scale for the bending moments is $12\times1000\times2$, or 24,000. The ordinates in C measured in inches are then multiplied by 24,000 lb. per in. to get actual bending moments in in.-lb.

In making the M/I diagram as shown at D, it should be noted that I for a solid shaft is $0.0491\ d^4$. The values for d are given in diagram A. Divide the bending moments M, as obtained from diagrams C by the corresponding values of I and place the quotients on the lines at the top of diagram D, as shown. Draw in the lines of the diagram and put in the horizontal dimensions in inches across D, producing an irregular polygon. The centers of gravity of the individual parts must be found longitudinally. This work of locating the center of gravity is expedited by the method described in the accompanying table, which locates the center of gravity from the upper end of the figure. Thus for a triangle the center of gravity is one-third of the altitude measured up from the base. For a square it would be midway between opposite sides. The values are given in terms of the smaller altitude divided by the larger altitude, or y/Y. Knowing the base line lengths in inches, the ordinates for the deflection diagram F are located easily. Next, find the areas of the individual parts of D. For example, that at the left is $1{,}291\text{x}\frac{1}{2}\text{x}23$ or 14,850. The next toward the right is the mean height, $734\text{x}\frac{1}{2}\text{x}5$, or 1,870. All this work is done by slide rule. These values are placed below D.

The second force polygon consists of the areas of the M/I diagram D laid off vertically in E, and shifted parallel over to F in the same manner as the bending moment diagram C was shifted from B. Scale the ordinates of F in inches, and place them on the diagram. To calculate the multiplier or scale for the ordinates of F, the horizontal length scale is 12 in. to 1 in., the vertical scale of E is 10,000 lb. to 1 in., and the pole height h is 1.65 in., making the multipler $12\times10{,}000\times1.65$, or 198,000, as determined by slide rule. Divide 198,000 by the modulus of elasticity, 29,000,000, giving 0.00683 for the multiplier.

The deflection ordinates of F in inches, multiplied by 0.00683 give deflections at the several points, in inches. With these values of deflection, the critical speed in r.p.m. can be found using Dr. Baumann's empirical rule derived from steam turbine tests. This rule which takes into account some practical factors not ordinarily considered, such as bearing effects, is

$$N = 195\,(1/y)^{1/2}$$

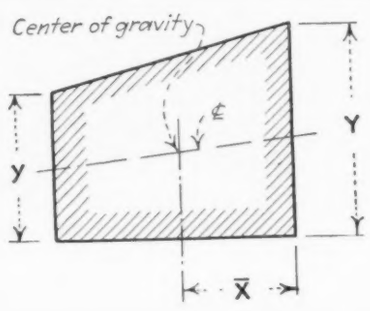
In this equation N is the critical speed in r.p.m., and y is the maximum deflection for one load between two bearings, or several loads reduced to one equivalent load between two bearings. In the example given above the maximum deflection is 0.00922 in., giving a critical speed of 2,031 r.p.m., by slide rule computation. It may be therefore concluded that operation at the four-pole synchronous speed of 1,800 r.p.m is safe as regards whipping.

The actual drawing time for these problems was less than an hour, including all calculations. The original diagram was made on a letter-sized sheet, convenient for filing with the records for the job. As graphical work is self-checking, it is well suited for designers working independently.

Tables for Finding Centers of Gravity of Trapezoidal Sections

y/Y	x	y/Y	x
0	0.333	0.6	0.458
0.1	0.360	0.7	0.470
0.2	0.389	0.8	0.482
0.3	0.410	0.9	0.491
0.4	0.428	1.0	0.500
0.5	0.444	...	.....

The distance $\overline{X}$ is found by multiplying the factor x in the table by the base line



Case Histories in Product Design—V

T. J. MALONEY
New Jersey Zinc Company
and
GEORGE SWITZER
Product Designer

HONESTY of treatment of a material is a feature this month's two designs worked out in plastics, cases 15 and 16. Evolutionary steps, always so informative to a designing engineer, characterize case 14. Substitution of materials, resulting in improvement in appearance and performance, and reduction in cost, is the high spot of case 13.

Product Case History No. 13

PRODUCT—Ditto Duplicating Machine.

MANUFACTURER—Ditto Inc.

DESIGNER—Engineering Division, Ditto Inc.

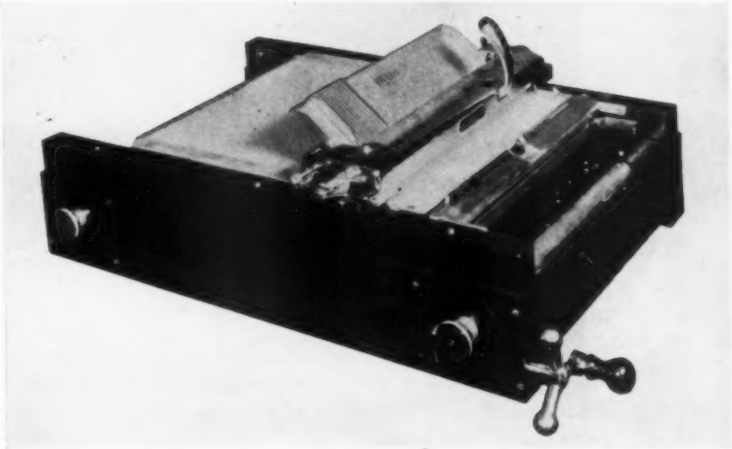
DESCRIPTION—As the photographs comparing the old and new machines show, they are radically different in appearance. Correspondingly radical changes were made in the design and manufacture of the mechanical portions of the new model. The old frame was constructed of two heavy gray iron castings bolted together. In the new machine a combination steel stamping and zinc die-casting frame containing the simplified winding mechanism improved the appearance and was produced at a decided saving in weight and manufacturing cost. Machining, a large item in the old frame, was practically eliminated, and assembly cost reduced.

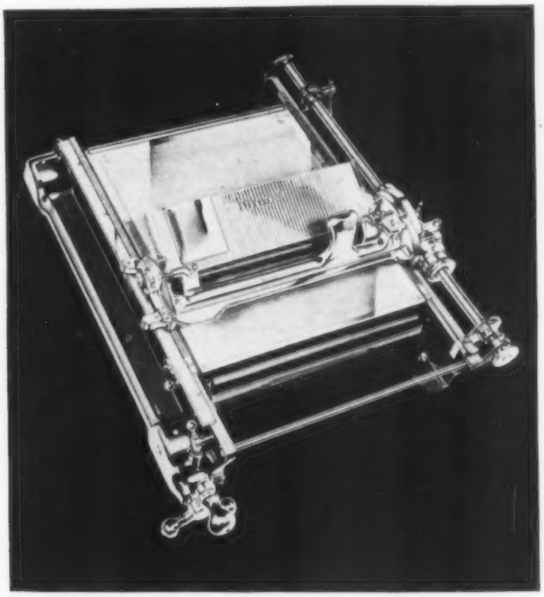
The carriage was changed from an aluminum mold casting to a zinc die-casting. Again large manufacturing cost savings were made through the elimination of machining, and by providing an easier plating surface. The zinc die-casting carriage was an improvement in appearance design also. The margin bar, another aluminum mold casting replaced by a zinc die-casting, increased the cost saving.

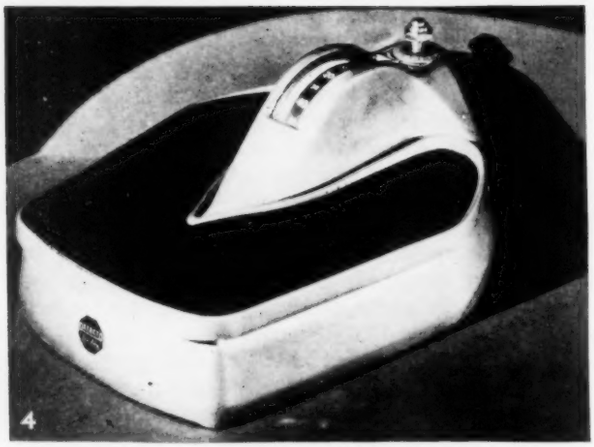
Office machinery is notoriously ill-treated, particularly in regard to lubrication. To overcome any laxness on this machine the engineering department devised a method of casting an Oil-Lite oil-less bushing as an insert in die-cast bearings.

Another important change was made in the bed plates of the machine. On the old models they were of steel, heavily plated to prevent corrosion from the water, ink and acid in the operation. The cost was very high, and an etched aluminum plate was substituted at a saving, but still the etching made the cost relatively high. By changing to a controlled semi-perforation they now get the same effect without any additional cost, since there are manufacturers with equipment on hand able to furnish the plate in standard sizes. An anodic treatment is given the aluminum plate that makes a surface as hard and corrosion resistant as the original chromium plated steel. From an operating efficiency standpoint a further improvement is noted, because the perforations stand above the plate, while the etched surface was below the general plate

New (left) and superseded models of Ditto duplicating machine in which substitution of materials led to design changes that resulted in better performance and lower cost







Four models of the Detecto bathroom scale that emphasize the evolution of the design over a period of ten years

level. This change eliminated a vacuum lock that occurred when the roller operated, and interfered with the printing operation often causing trouble with the older machine.

Due to these and other savings the new machine retails for a lower price than the previous model, and still allows the manufacturer a greater margin between his own manufacturing cost and his selling price.

SALES RESULTS—The change has brought appreciable results in dealer and customer enthusiasm and as a result in sales in a demoralized market. It is interesting to note that the engineering division made models of the new machine as projected by an artistic designer, incorporating all their changes and then produced a more compact, a lighter, and a better synchronized machine. The startling results of these material changes through changes in materials are already leading to further manufacturing efficiencies.

Product Case History No. 14

PRODUCT—Detecto Bathroom Scale.

MANUFACTURER—The Jacobs Bros Co., Inc.

ENGINEERS—Engineering Department of Jacobs Bros.

DESIGNER—Henrik Hoyer.

DESCRIPTION—In the accompanying illustrations appear four of the important steps in the evolution of the bathroom scale from a purely utilitarian object to a piece of domestic equipment as attractive as it is useful. Note the progressive changes that mark the casing which was at first just a cover for the mechanism, but now combines greater convenience with real beauty.

Features that characterize the new model are the division of the foot room, the protected dial, the non-tipping base and the recording device. Although the foot room is about the same in this model as in the previous one, the new one looks larger because of the division. Protection of the dial is an obvious advantage. The non-tipping feature appeals to every user, but more particularly to the more ponderous ones, to whom a firm support is essential. The recording device is simply a gadget, of course, but it is a real convenience to users who want to watch daily weight changes.

SALES RESULTS—The periodic introduction of new and improved models has kept the sales curve of Detecto scales pretty steadily on the upward path. 1932 was the peak year, but even better results are expected from the new model in 1933.

Product Case History No. 15

PRODUCT—Salt and Pepper Shakers and Spice Containers.

MANUFACTURER—The Reynolds Spring Company.

DESIGNER—Van Doren and Rideout, Inc.

DESCRIPTION—The excellent properties of molded plastics for tableware products have long been recognized. Because of their non-corrosive qualities and attractive colors, such plastics have been especially popular for salt and pepper shakers, but the fundamentals of good design had been neglected. The Reynolds Spring Company asked Van Doren and Rideout to prepare designs.

ENGINEERING DIFFICULTIES—The designs for such salt and pepper shakers had to take into consideration the necessity for rapid molding and consequently light sections for quick cure. In carrying out

the design, Van Doren and Rideout, Inc., felt that even the smallest details should not be neglected. Hence, even the perforations in the top have been made definitely in pattern with the ribbing on the sides, thus replacing the familiar star or circular openings which bore no relation to the design of the shaker.

SALES RESULTS—Literally hundreds of thousands of these shakers have been sold through chain outlets in a short period. Today they are in widespread use. Isn't this a test of the efficient salesmanship of good design? For after all, salt and pepper shakers of myriad, heterogeneous varieties are found in most every store a woman enters.

Product Case History No. 16

PRODUCT—Midget Radio.

MANUFACTURER—Colonial Radio Corporation.

ENGINEERS—Engineering Department, Colonial Radio Corporation, and J. B. Neal, Norton Laboratories, Inc.

ARTIST—Jan Streng.

DESCRIPTION—The Colonial Compact is a five-tube, all-wave, superheterodyne, aimed at a price bracket high enough to allow a better than average dealer margin. Since no radical mechanical improvements could be added, Colonial executives decided to base their request for a $30 price on greater visual appeal. Jan Streng, a New York designer, was selected for the work.

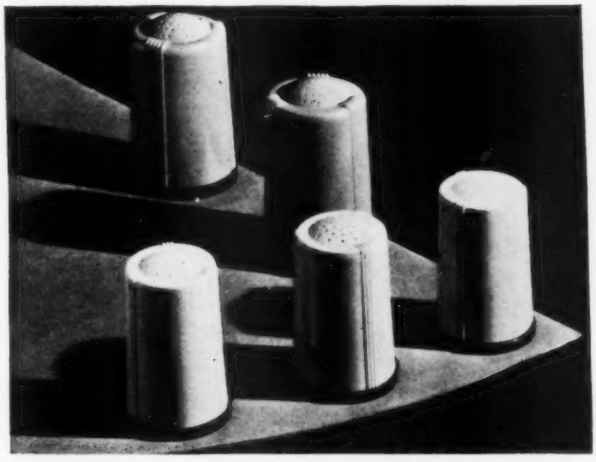
Streng's investigation of midget radios disclosed the fact that most manufacturers still considered radios as furniture, even though they had shrunk from console to cigar-box size. With this furniture background, they were even treating midgets as furniture instead of as accessories like lamps or electric clocks, and even when they forsook walnut veneers for the pre-finished, one-piece, easily-assembled molded plastic cabinets, they still specified "imitation walnut" molding compound. Streng saw the error, in that the public looked upon "walnut" molded cabinets as cheaper substitutes for real wood, and although various factors dictated a molded plastic cabinet, the designer knew that honest and intelligent treatment of the synthetic material would result in a rich-looking object.

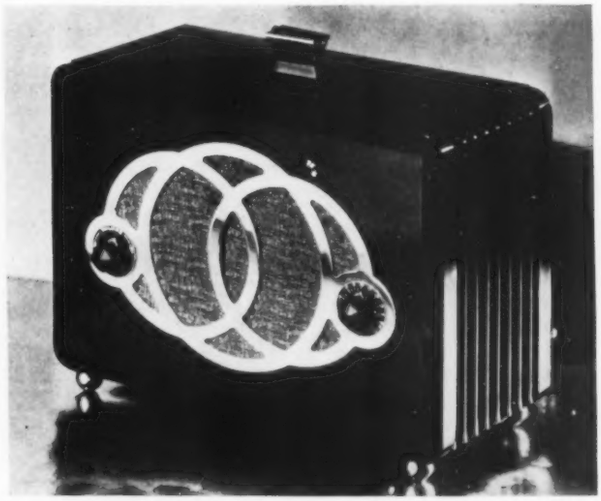
The new cabinet is "modern" in that it is geometric in conception, but it avoids any suggestion of the "modernistic"—harmonizing with almost any home furnishings. Geometric lines were used to lower the initial die cost, and also because of the greater ease with which the eye muscles move in geometric paths. The simple lines also look restful, drawing eyes instinctively in the average "agitated" home-scene or retail radio display.

Since the designer's engineering limitations consisted mainly of fixed chassis and speaker dimensions and the necessity for adequate ventilation, he adhered to the normal rectangular box, vented on the bottom. The bottom vents called for the use of a split mold in a one-side-acting press, since the entire cabinet was to be molded in one piece, and Streng found that vertical side flutings and a slightly pyramided top could be added merely by using a four-side-acting press. The verticals at the sides made the cabinet look lighter and less deep. The grille, of polished chromium plate, is a triple repetition of the normal dial motif, the circle, a form far easier on the eyes than the tortuous, wandering lines of the average grille. Ball-feet and handle are zinc die-castings, chromium plated. Together with the grille, these functional parts in bright metal act as execllent contrasts with the smooth surfaces of the black Durez cabinet. All exterior rivets, screw-heads, etc., are eliminated.

SALES RESULTS—Although introduced but a few weeks ago, the Colonial Compact met with an unexpected dealer and consumer response. At the present writing, sales are far ahead of production, several sizable orders having been lost through lack of immediate deliveries.

A design for salt and pepper shakers to be sold through chain store outlets that has been successful in a highly competitive market





This product design problem concerned itself mainly with improved appearance, and re-valuation of small radio as an accessory rather than furniture. Plastic material was used honestly, instead of as "wood-substitute"

COMMUNICATION and COMMENT

Spring Stresses, Index and Other Factors

FREDERICK FRANZ
Consulting Mechanical Engineer

In the July *Product Engineering*, W. M. Griffith in his article, "Engineering Standards for the Design of Springs," brings out several requirements in spring design that generally have been neglected. The writer agrees with Mr. Griffith that the allowance of 10 per cent of the wire diameter is sufficient to prevent coil contact and small enough to avoid appreciable loss of work available from the spring.

Another requirement that was emphasized is the necessity for allowing maximum fiber stresses much below those generally recommended in technical journals and handbooks. But for small wire springs subjected to infrequent stress cycles, there is no reason for running the risk of failure from high stresses of 90,000 lb. per sq. in., that Mr. Griffith recommends. Only in extreme instances where space is at a premium such as the main spring of a wrist watch should high stresses be utilized.

There is no reason why Mr. Griffith should reduce the allowable fiber stress in tension springs under that allowable in compression springs. The stresses in both springs are shear stresses but under the same load a compression spring increases its effective coil diameter when stressed while a tension spring reduces it. Thus, a higher nominal allowable maximum fiber stress could be recommended for tension springs than for compression springs.

Vigorous exception is taken to the statement that the best proportioned helical tension or compression spring has a spring index of about nine. The spring index to be designed into a spring is really a function of the problem, that is, the maximum and minimum working length of the spring and the maximum and minimum forces desired. If stiff springs are required, a small spring index must be used; for soft springs a large spring index is required. Large spring indexes carry heavy penalties in the form of extremely large wire diameters for a given load. It is necessary to use a low spring index when space is at a premium and when large forces, but only small deflections, are required. For example, springs for sub-press dies give satisfactory service when designed with a spring index of only two.

A requirement of torsional springs not considered in the drawing shown by Mr. Griffith is that springs must be open wound with sufficient space between the coils to avoid endwise enlargement of the spring when it is wound up. The amount of the allowance depends on the wire diameter and the amount of angular winding.

Another procedure shown on Mr. Griffith's standard drawings that must be avoided is specifying both the complete dimensions of the spring with limits and the forces which it should yield, with limits. One or the other may be specified but not both. If both are specified, a spring may be produced that is within the dimensional limits but outside of the load-deflection limits.

Draftsmen and Their Feelings

P. BONSALL

Drawing dimensions are a source of irritation to many tool and production departments. There are many instances where a part is located from the opposite end to that at which its dimensions originate, apparently for no good reason. It is generally understood that the function of the drawing office is to make crooked paths straight for the shop department; however, from the manner in which essential dimensions are sometimes disguised, it is difficult to determine whether it is a game of hide-and-seek or a desire to produce a drawing of great artistry.

Although shopmen's sketches usually lack symmetrical lines, block letters and neatly ruled borders, they do at any rate express in shop language that which is required.

It is my opinion that pride of craftsmanship should rate higher than the ability to display versatility with the compass and eraser. For example, in designing tools the essentials should be (1) justification of the tool expense on the basis of the volume of work to pass through the tools; (2) ease of handling, foolproof clamping, aligning facilities for the tool operator; (3) generous provision for the outlet of cutting compound.

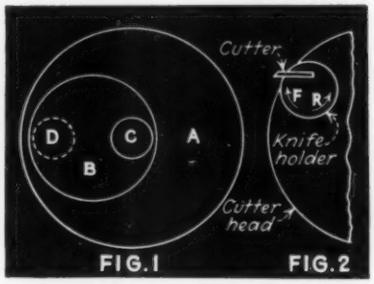
These apparent platitudes are so often neglected by the draftsman that the basis for this complaint is far from imaginary.

Circumferential Adjustments

JOHN E. HYLER
Peoria, Ill.

A simple and effective means of making an eccentric with an adjustable throw is shown in Fig. 1. The eccentric *A* is mounted upon an eccentric core *B* so that it can be rotated, and is provided with means for locking it in any desired position. With the shaft *C* upon which the eccentric is mounted in the position shown, the shaft and the outer rim of *A* are concentric, the throw of the eccentric being zero. If *A* is rotated upon *B* one-half of a revolution, bringing *C* to the position shown as *D*, the eccentric has its maximum throw. It is capable of infinite adjustment between these two points.

Another type of eccentric adjustment permits grinding the knives or cutters



The principle of adjustable eccentricity has many applications. In Fig. 1 it is used to obtain a variable throw crank, in Fig. 2 to effect a change in cutter setting

in a cutterhead while the cutterhead is in motion, as shown in Fig. 2. The knifeholders are fixed in suitable pockets around the rim of the cutterhead and can be adjusted either in direction *F* or direction *R*. After being ground in the position shown, the knifeholders are turned back and the cutterhead is ready for use.

Another circumferential adjustment is one used on a double-end tenoner with a double-chain feed, a chain running on a pair of sprockets at each end of the machine. For cutting the material square, dogs on the chain are squarely across from one another. For cutting at an angle the dogs on one side are set a given distance ahead or behind those on the other side. Adjustment is accomplished by making the sprockets on one chain in two parts, the rim being rotatably adjustable upon the hub. Thus, the chain can be set ahead or behind any desired amount at any time.

The Value of Old Drawings

Years ago, the W. J. Savage Company, built a machine for cutting beer barrel staves from split white oak blocks. This machine was a clumsy affair. The last one was built in 1911, more than 20 years ago.

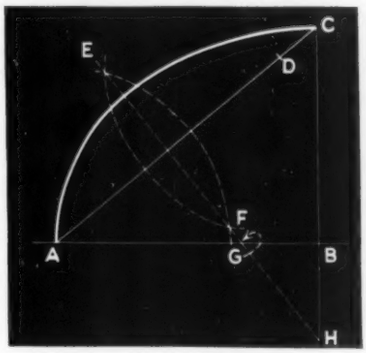
With the return of beer to legal standing, somebody remembered about the old barrel stave machines. The musty drawings were found and turned over to the engineers for modernizing, and the machine was simplified and improved. A circular describing this improved machine was sent to barrel manufacturers, the new model being shown in a picture. The net result was a long list of orders for barrel stave machines with particular emphasis on delivery dates.

Drawing the Ellipse

H. E. Gottlieb

The following method for laying out an ellipse with the major and minor axes given has been found to be satisfactory and rapid.

Lay off the semi-major and semi-minor axes *AB* and *BC*, and draw the line *AC*. Lay off point *D* making



Mr. Gottlieb's method of constructing an ellipse

the distance *CD* equal to the difference between distances *AB* and *BC*. Erect a perpendicular bisector *EF* to the line *AD*, and extend *EF* to *G* and *H*. The short radius is *GA* and the long radius is *HC*.

Re-Invention and the Younger Engineer

To the Editor:

Re-inventing suggests duplication of effort. It is therefore quite natural that the methods of eliminating it should be given thought, although it should be pointed out that re-inventing does not necessarily represent waste. There are any number of possibilities which have been conceived in the past and were not worked out either because of insufficient financing or because the general art at that time had not progressed to a point where these ideas could be practically utilized. With the advances made in the meantime in materials, detailed design features and manufacturing methods, it is frequently possible that that same idea can be made useful now. In fact, I believe that as much benefit can be derived for humanity by review and revival of old ideas as can be gained from entirely new ideas.

Younger engineers, if they possess any imagination and any inventive ability at all, are bound to make numerous re-inventions until they become familiar with the art. Such ingenuity should rather be encouraged than discouraged because, as in every other activity, practice is useful and essential. Of course, these younger men should not be permitted to spend an unreasonable part of their time and should not incur expenditures in connection with ideas which to the older men are known to be unproductive of useful results. This can be taken care of readily if the younger engineers disclose and discuss their ideas with the older and more experienced men.

But there are various reasons why younger engineers may hesitate to disclose their ideas. One of them is the fear of ridicule which, however, can be readily dispelled by a tolerant attitude on the part of the older men even to ideas that to them may appear to be absurd. Frequently, instead of bluntly turning down a suggestion, it may be good policy to refer the younger engineer to related literature or similar data so that he can find out for himself the state of the art.

Another reason why younger men are hesitant to disclose ideas is the fear that somebody else will appropriate them. If the older men are trustworthy the younger men will soon find this out and lose their hesitancy. If this condition does not obtain it is simply too bad for the organization. However, in either case, it is a good practice to have the younger engineers always immediately reduce their ideas to writing.

There are cases, of course, where new ideas develop during conversation between several people, where it is difficult to be certain about the contributions of the various people, and where it is even more difficult to judge which of the contributions constitutes possible invention. The only solution for such difficulties is a liberal attitude on joint inventorship.

Beside the above fundamentals there are, of course, certain aids and facilities that will avoid unnecessary wastes. If the older members of an organization are unaware of anticipation of an idea, a brief patent search can be made before filing an application. The same action, of course, is desirable before any appreciable expenditures are made for carrying through developments. But since an exhaustive search is costly it is frequently cheaper simply to prepare and file an application and to take certain limited charges with regard to development expenditures. Altogether, there is no absolutely sure way of guarding against anticipations, and therefore it is necessary to take reasonable business risks.—R. E. Hellmund

Chief Engineer
Westinghouse Electric & Mfg. Co.

Avoiding Re-Invention

To the Editor:

In regard to the article, "Avoiding Duplication in Development Work," appearing in the July *Product Engineering*, so long as competition exists I can see no possible way of eliminating re-invention in the manufacture of knitting machinery where development is so frequently governed by trends in style.

As an illustration, the hosiery worn by men about twelve years ago was

almost without exception of a plain and conservative design. But within a year or two there was a demand for a slight fancy effect, which was supplied by the machine builder through the use of an attachment for producing narrow vertical lines brought about by knitting successive loose or drop stitches. Then came a demand for a stocking that would be a trifle more attractive in appearance, and this was again met by the machine designers through the addition of horizontal stripes in the fabric. Next was a request for a different color in the vertical stripes from that of the body of the stocking. Then followed figured designs and the jacquard patterns, and later several colors knitted on various groups of needles. Each required new developments in the knitting machines. Now we have the modern machines which are capable of knitting patterns composed of yarns of various colors, automatically wrapped around adjacent needles, thereby producing pleasing effects.

With all manufacturers of knitting machines striving for the same result, in the development process a number of inventors and designers have been working along the same lines. Some results were bound to conflict, and could probably be classed as re-invention. But such re-invention cannot be eliminated as long as experimenting is carried on behind closed doors.

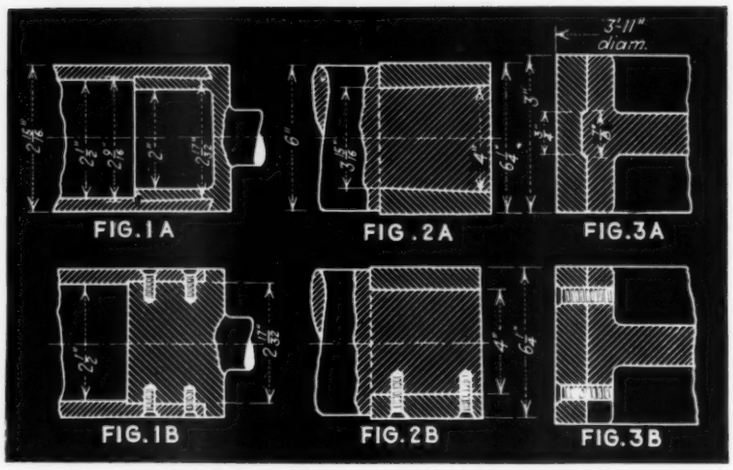
The designer can save himself much time and trouble, however, by keeping in touch with new materials and appliances which have been developed for his benefit by reading a good magazine specializing in product engineering. — STANLEY R. SHELMIRE
Wilmington, Del.

Reflectivity of Enameled Steel

To the Editor:

On page 231 of the June *Product Engineering* a request was made for information on the reflectivity of white enameled steel. If the enameled side is exposed to radiation, the base metal will have no effect. Coblentz and Hughes in the *Bureau of Standards Technologic Papers*, Vol. 18, 1924-25, pp. 171-187, describe tests on the emissivity of sheet iron covered with white vitreous enamel. The emissivity, as given in Table 1 of the article, was from 98 to 100 per cent that of white paint, and from 95 to 98 per cent or 96.5 per cent average, that of lamp-black paint, when exposed to sunlight. According to Coblentz in the *Bureau of Standards Bulletin No. 196*, 1912, the emissivity of lamp-black paint under conditions equivalent to sunlight is 96.8 per cent. Therefore, the emissivity of white vitreous enamel can be taken as 0.965x96.8 or 93.4 per cent that of a black body, and the reflectivity is accordingly about 6.6 per cent. The reflectivity will be very little affected by the color of the enamel and should vary but little over a wide range of wave lengths.

—C. J. PHILLIPS
Physical Laboratory
Corning Glass Works



The right way and the wrong way for three types of sleeve fastenings

Attaching Light Pulleys

A. M. MANN

A convenient way of attaching light pulleys that has met with success on several occasions is shown in the illustration. The design served particularly well in providing a means of ready attachment and dismantling, and is relatively inexpensive. For reasons of safety, driven keys as well as setscrews were barred, but the tapered and threaded boss and the round nut proved good substitutes. In the illustration *A* is a key for driving. The boss *B* has a slight taper and is slitted like a spring collet after the screw threads have been cut. A steel nut, *C*, has slots for a spanner wrench.

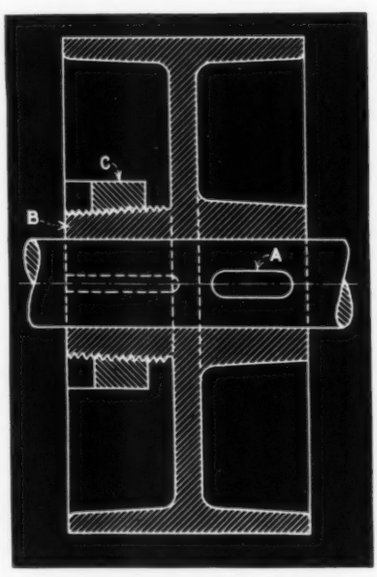
Right and Wrong Fastenings

A. L. FOREMAN

What has been proved to me to be the right and wrong way in association with several commonly-used machine parts is given in the accompanying illustrations. In the three examples given here and shown in the accompanying illustrations, the proper method is shown in the upper part and the incorrect method is shown in the lower part of the illustrations. As the illustrations are virtually self-explanatory, only a few words of description are required.

In Figs. 1*A* and 1*B* are shown light tubular rollers, such as are used to a considerable extent in machinery for rubber factories and paper mills, and on printing presses. At *A* is shown the approved way of fixing the journalled ends, merely by a reverse-taper shrink fit and without screws. At *B* is illustrated the traditional but improper method.

Figs. 2*A* and 2*B* refer to plungers having cast-iron bodies and phosphor-bronze sleeved ends, such as are used for compressing carbon dust in machines for manufacturing dry cells. At *A* is shown the approved way of attaching the sleeve. Here also use is made of the reverse-taper shrink fit which permits the elimination of screws. At *B* the old and cumbersome way is shown, which method



Small pulleys are readily attached or removed when clamped by a threaded collar

gives no end of trouble as the screwed rivets must be drilled out when a new sleeve is needed.

Steel-tired cast-iron drums are shown in Figs. 3*A* and 3*B*. Such drums are used to a considerable extent in cable work and machines for wrapping insulation on wire. At *A* is shown the approved method of shrinking on a raised tapered part, no screws being required. At *B* is shown the design wherein screws are required for holding the tire.

In each of the approved methods illustrated here the principal feature is that the fastening is such that it is inexpensive and it is easy to replace the parts that are subjected to wear.

Magnesium Copper in Zinc Alloys

In the discussion of the properties of the different zinc alloys, as printed on p. 223 of the June *Product Engineering* the last sentence of the third from the last paragraph reads, "These properties (resistance to disintegration, high strength and ductility and better metal flow) are largely a function of the manganese copper content of the zinc."

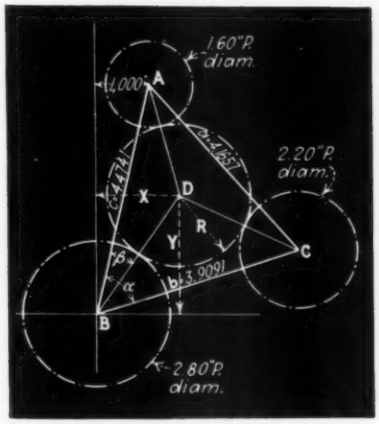
This should read "function of the magnesium copper content of the zinc."

Designing Mongrel Gears

C. A. Wiken
Rockford, Ill.

In the design of multiple-spindle drilling machines the spindle speeds are determined from the diameter, feed per revolution and cutting speed for each drill. As in the acompanying illustration, the position of each drill is fixed, but the pitch diameter and position of the common drive or mongrel gear cannot be easily determined. In most designs, cut and try methods do not produce a result of sufficient accuracy.

For example, what is the location and pitch diameter of the mongrel gear in the layout illustrated, accurate to four decimal places?



An analytical solution for the dimensions *X*, *Y* and *R* is required

Greater Accuracy With the Slide Rule

E. J. Carter
York, Pa.

Through constant use of the slide rule, engineers become chronically weak in multiplication by longhand, and worse in addition. Since the slide rule can hardly be dispensed with, the following method of obtaining accurate decimal products on the slide rule will often be of use. The same method also can be extended to division when it becomes necessary to obtain more than three significant figures.

To illustrate the possibilities, suppose that the spacing chord for 20 holes on an 18-in. diameter pitch circle is required. The chord constant is 0.15643, which is separated into 0.15 plus 0.00643. Multiplying each of these out separately on the slide rule:

$18 \times 0.15 = 2.70$
$18 \times 0.00643 = 0.1157$

Adding, 2.8157 in. chord

Checking this calculation by longhand multiplication gives a 4 in the fifth decimal place, but as it is usually sufficient to give chords to the nearest thousandth, this method is satisfactory.

To reverse the process, and divide 2.81574 by 18 on the slide rule:

$2/18 = 0.11111$
$0.815/18 = 0.0452$
$0.00074/18 = 0.0000411$

0.1563511

This sum differs from the exact answer by 8 in the fifth place.

DEFLECTIONS

TOY LAMPS AND MARBLES

Manufacturers of lighted toys, such as pocket flashlights, miniature automobiles, motorboats, and the like, demanded tiny electric lamps that would emit a powerful spot of light, resist breakage, and operate from a single dry cell small enough to be installed in the toy itself. The problem was to get a solid glass lens of optical characteristics necessary to give an intense beam of light. But when a minute quantity of glass is gathered into a small ball it is put under a terrific strain and cracks readily. To attach such a small sphere of glass to a fragile stem tubing to make the bulb was found to be impossible. Marvin Pipkin, of the General Electric Company, was given the problem. Observing a group of small boys playing marbles, some of which were clear glass "aggies," he got the inspiration of attaching them to the stem tubing to serve as the lens.

The net result was that the "aggies" provided just the light "spot" that was required, resulting in a line of General Electric toy lamps rated at 1.25 volts and 0.3 amp., giving forth a surprising amount of light and at the same time highly durable.

Kiddies playing with marbles furnished the idea.

TINY MIRRORS

Mirrors only $\frac{1}{64}$ in. wide, $\frac{1}{32}$ in. long and 5/1,000 in. thick are used regularly in the General Engineering Laboratory of the General Electric Company. A single one of these mirrors weighs only about three one-millionth of an ounce. They are used in electromagnetic oscillographs, each mirror being suspended between magnets by two wires each 0.0003 in. in diameter, or about one-tenth the thickness of a human hair. The mirrors are made by silvering a microscope cover glass, diamond ruling it, and breaking it into 2,048 pieces per sq.in.

HEIGHTS OF ECONOMY

Gold, silver and platinum are highly corrosion resistant, but solid sheets or rods of precious metal are too expensive; electroplating is porous. By fusing a thin sheet of the precious metal to a heavy plate of base metal, and then drawing or rolling, a sheet is obtained with a thin covering of solid precious metal 0.001 in. or less in thickness. Rods and tubes are made in a similar manner. Such "laminated" metal is used for pressure diaphragms, electrical contacts, springs and other parts, the base metal being selected to suit the mechanical requirements.

· NEWS ·

Abrasion Resistance of Cast Iron

According to tests reported by J. S. Miller, research director of the Lehigh Navigation Coal Co., Ni-Cr cast iron has approximately three times the life of ordinary plain cast iron when used for chute plates. These chute plates are subjected to the abrasive action of rock and refuse and when made of plain cast iron had to be replaced at approximately 200-day intervals.

By the substitution of a 2.00 per cent nickel—0.60 per cent chromium cast iron, the plates lasted 688 days in this service. This material is now being used by the Lehigh Navigation Coal Co. for troughs, gyrator nozzles and other parts required to resist unusual abrasive action. The alloy is added to a base mixture sufficiently low in silicon to give a white or chilled fracture.

Standard Purchase Form for Gears

In May of this year the American Gear Manufacturers Association adopted a recommended practice for gear purchasers. This recommended practice has now been published in the form of an eight-page leaflet, which is available upon application to the American Gear Manufacturers Association, First National Bank Bldg., Wilkinsburg, Pa.

According to the gear manufacturers, there is a lack of understanding by many of the purchasers of gears as to the information required by the manufacturer in order to quote upon or make the gear as desired by the user. For this reason, the booklet sets forth simplified forms to be filled out when ordering gears. A sketch accompanies each form with dimension lines drawn in, the dimensions to be filled in by the engineer specifying the gears. Attention is called to the fact that the important dimensions should be specified and those should also indicate the limits of allowable error. Other dimensions should be given and marked "approximately only," thereby allowing the gear manufacturer to quote on gears to his standard dimensions and enabling him to use available tools, thus avoiding unnecessary manufacturing expenses which would be reflected in the price of the gears.

Types of gears for which specification forms and sketches have been prepared include: bevel, helical, herringbone, spiral, spur and worm gearing inquiry forms.

Creep Resistance Data

Results of a study of the creep resistance of 15 alloys of the nickel-chromium-iron group, covering a range from 1 to 75 per cent Ni, and from 3 to 55 per cent Cr, are reported in *Research Paper No. 572*, published in the June *Bureau of Standards Journal of Research*.

The tests reported showed that at 1,000 deg. F., alloys containing little or no iron, 50 to 80 per cent Ni, and 20 to 50 per cent Cr, had the greatest creep resistance, while at 1,600 deg. F., the alloys having the greatest creep resistance were those containing approximately equal parts of nickel, chromium, and iron.

Carbide precipitation was most pronounced in the alloys of higher chromium content, in both the iron-chromium alloys and the iron-chromium-nickel alloys. Prolonged heating of both stressed and unstressed specimens did not produce pronounced changes in structure of any of these alloys except those containing 50 per cent or more of nickel.

International Automotive Congress

The names of many noted men will be found in the list of speakers who will address the meetings of the International Automotive Engineering Congress sponsored by the S.A.E. to be held at the Palmer House, Chicago, Aug. 28-Sept. 4. In addition to this, seven S.A.E. past presidents will participate in the meetings.

Among the prominent foreign visitors will be Georges Broulliet, of Paris, France. He is a member of the French Society des Ingenieurs de l'Automobile. His paper will discuss the problem of independent springing. Another prominent foreign visitor will be Lawrence H. Pomeroy, of the Daimler Co., Coventry, England, who will discuss "What is the Matter with American Cars?"

W. D. Stout, of Stout Engineering Laboratories, will talk on "The Future of Individual Transportation."

Other papers scheduled to be presented before the Congress include: "Engine Mountings," by Alex Taub, Chevrolet Motor Co.: "Budgeting Body Construction and Tool Costs," by N. H. Manning, Briggs Mfg. Co.; "Air-Conditioning and Relative Refinements for Automobile Body Design," by F. A. Moss, of George Washington University.

Motor trucks and motor coaches, transportation and maintenance of aircraft and aircraft engines will be covered at the various meetings. Aside from the purely technical papers that will be presented is one entitled "The Engineer's Place in the Economic Picture," by C. F. Kettering of General Motors. The timeliness of this paper makes it of special interest.

What Makes a Successful Engineer?

Discussions of the lack of engineers with commercial instincts, broad viewpoints, and a spirit of public service have been so numerous that it has become an old story. But in a pithy address before the annual meeting of the Society for the Promotion of Engineering Education at Chicago, Ralph Leavenworth, general advertising manager of the Westinghouse Electric & Mfg. Co., summarized this whole question in a striking manner that created much discussion and comment among the engineering professors responsible for the preliminary training of American engineers. In outlining the requirements for financial success or failure in the engineering profession, Mr. Leavenworth stated:

"A young engineer may circumscribe his activities within a circle bounded by his slide rule, his table of logarithms, and his books and instruments, and live a life of calculations, curves and drawings. He may even gain for himself among his associates the rating of a wizard, a mathematical genius.

"Or he may use his engineering education as a base of operations from which to explore the many activities comprising modern life. His horizons will expand, his interests multiply,

and the talents that he has so carefully nurtured during his college life will raise him into a position of importance and give him general recognition in many circles.

"Perhaps he will be drawn into public life, in an avocational way in his own immediate community, or in the larger fields of municipal, state or government service. Great personal satisfaction accrues to the man who renders such service with ability and his fellow citizens delight to do him honor.

"Success in each of these fields requires the ability to write and speak effectively, humanly, persuasively. It requires the use of illustration in something more than the purely technical style.

"It is increasingly important, to be successful in this profession, for a young engineer to be able to write intelligent, interesting, concise and informative articles for publication. No wonder I say that the engineer's education begins with the English language.

"Suppose the engineer knows all the technical intricacies of a certain subject but is called upon to present the advantages of his apparatus for consideration by a board of directors, men trained in general business and finance, but not engineers. This calls for a different kind of writing, and a different kind of illustration from that of the standard engineering report."

Mr. Leavenworth also indicated the importance of being able to speak before a crowd with assurance and confidence, as in addressing engineering gatherings, and stressed the importance of being able to write for technical and other publications.

Alloys of Iron and Silicon

Alloys of Iron Research, organized late in 1929 by The Engineering Foundation, now announces the forthcoming publication of the second of its monographs, "The Alloys of Iron and Silicon." The first monograph, "The Alloys of Iron and Molybdenum," was published in December, 1932.

This second monograph of the series will contain a critical resumé of all data on steel and cast iron containing silicon as an important alloying element. All of the research work of the world on silicon structural steels, silicon electric steels, and silicon acid-resisting irons has been reviewed and summarized comprehensively. Included also in the book is a complete discussion of the pure alloys of iron and silicon.

The scope of this work can be judged from the fact that the abstracts were obtained by a review of most of the important journals printed in English, German, French and Swedish, from 1890 to date, representing a review of nearly 5,000 technical papers. This is probably the largest collection of classified data on the whole field of alloy steels and cast irons in existence, and is being made available for use of scientists, researchers, and engineers who desire a reliable summary of the past work on alloy steels and alloy cast irons.

Veneered Steel Panels

Development of a fiber-coated metal, a steel sheet with a fiber coating to provide anchorage for an adhesive, is reported by the Mellon Institute of Industrial Research, of Pittsburgh, Pa. The fiber coating provides an anchorage for resin adhesives, thereby giving a fiber-reinforced glue line with both fibers and adhesive attached to the metal. It is claimed that this bond is approximately 45 per cent stronger than is obtainable by the present methods of attaching the veneer to etched steel sheets. A further advantage lies in the fact that the fibrous layer serves the important function of supplying a cushioning action between the relatively non-compressible steel sheet and the veneer layers, thus insuring a more uniform contact and adhesion in the laminating operation.

Veneered steel panels of this type can be made in one pressing operation by attaching preformed laminated veneer to the backing. Attractive surface effects can be obtained by selecting colored and printed fibrous layers for the fiber coating of the metal, saturating this with resin varnish, drying, and pressing to cure the resin and to secure the desired finish. The most economical combination is that in which the metal is designed to supply all the desired strength, depending upon thin veneer layers only for the decorative effects.

Research reports relating to this fiber-coated metal which is designated as "Robertson Bonded Metal," and details on the field of application of this product can be procured gratis from the Mellon Institute of Industrial Research.

MEETINGS

American Society of Mechanical Engineers—Sixth national conference of the Oil and Gas Power Division, Aug. 23-26, Ritz Carlton Hotel, Atlantic City, N. J. Louis R. Ford, chairman, 29 West 39th St., New York, N. Y.

Society of Automotive Engineers—International Automotive Congress, Aug. 28—Sept. 4, Palmer House, Chicago, Ill. John A. C. Warner, general manager, 29 West 39th St., New York, N. Y.

National Metals Congress—Oct. 2-6, Detroit, Mich. W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio.

American Welding Society—Annual fall meeting, Oct. 2-6 Book-Cadillac Hotel, Detroit, Mich. Miss M. M. Kelly, secretary, 29 West 39th St., New York, N. Y.

EXHIBITIONS

Second American Exposition of Brewing Machinery, Materials and Products—Auditorium Hotel, Chicago, Ill., Sept. 23 Oct. 1. J. R. Nicholson, 55 W. 42d St., New York, N. Y., secretary, Master Brewers Association.

National Metals Exposition—Oct. 2-6, Detroit, Mich. W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio.

New Alloy Cast Iron

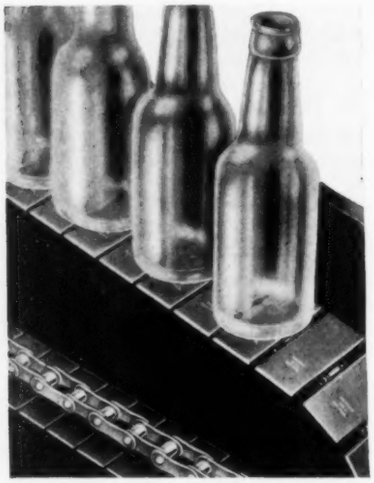
Bushings and liners for pumps and compressors handling hot liquids or vapors, automobile engine valve seat inserts and similar parts are subject to temperature changes that might cause a loosening or crimping of the liner or insert because of unequal expansion. This created a demand for a new corrosion and heat-resistant cast iron having at elevated temperatures approximately the same coefficient of expansion as plain iron. A chrome-nickel cast iron, claimed to possess such properties, was exhibited for the first time by the International Nickel Company at the annual convention and exposition of the American Foundrymen's Association in Chicago.

The composition of this new alloy cast iron is 28-32 per cent Ni, 4-5 per cent Cr, and the balance cast iron. It is said that this new material is tough, machinable, and maintains its properties without deterioration at high temperatures. It is a low-expansion cast iron and has a hardness of 140-200 Brinell, with a tensile strength of approximately 30,000 lb. per sq.in. Further data concerning this material is not yet available, but will be made public at an early date.

NEW MATERIALS and PARTS

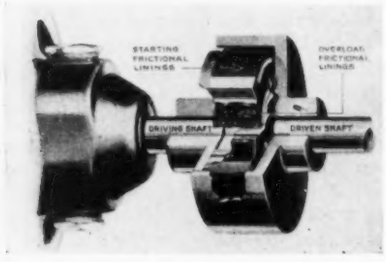
Whitney Conveyor Chain

For use on bottling, packaging and similar machinery requiring a built-in conveyor chain, is a roller-type, steel construction with double pitch dimension for use on standard cut sprockets with the rolls meeting every other tooth. Available in combinations of stainless steel parts or in all stainless steel in a wide range of sizes. Whitney Mfg. Co., Hartford, Conn.



Falk Coupling

Is said to perform four duties: starting, coupling, cushioning, and load limiting. This Falk-Rawson coupling is primarily an automatic starter. Claimed to provide smooth gradual starting and cushioning of overloads, reducing inrush current and permitting the use of smaller electric motors; also to fulfill functions of a flexible coupling and to eliminate the need of shear pin couplings. Between two drum-shaped driving and driven members are inserted two sets of floating segments, made of brake lining reinforced with lead, the amount of lead being designed to give the required centrifugal pressure. Outer segments are actuated by the driving member and the inner by the driven member. Outer shoes are designed to transmit rated motor torque, while inner shoes are designed for 40 per cent rated torque. For direct connection, coupling provides for moderate parallel and angular shaft misalignment and torsional shock overload. For overhung drive with pulley or V-belt drive, a type B unit is available. Also supplied in modified form for dual drives, for combined automatic starting and manual release, and as a brake. The Falk Corp., Milwaukee, Wis.



Improved Projection Lamps

Providing screen illuminations nearly twice as high as those recently available, incorporate a filament of biplane construction. One grid of coils is placed before the other and so staggered that a rectangle of light is presented to the lens. Special forming and heat-treatment of the filaments reduce warping or twisting of the coils, so that spacing between the coils is reduced. Claimed that the improved glass used does not devitrify and will stand higher temperature before softening. Available in the 100-volt class in 500-, 750-, and 1,000-watt sizes. Claimed, also, that bulb blackening is reduced maintaining the light output at a higher percentage of its initial value, and that bulb temperature remains lower throughout life. Increase in wattage for a given bulb size results from higher rates of forced ventilation. General Electric Co., Nela Park, Cleveland, Ohio.

"Armco" Deep-Drawing Steel Sheets

Made by a new process said to produce excellent ductility, uniformity of physical properties, ductility not impaired by temper cold rolling, permanent freedom from stretcher straining in a tempered condition, and no aging of ductility yield point, tensile strength and hardness. This combination of qualities is said to make this material well fitted for deep-drawing requirements. In the full-annealed condition the material will stretcher strain the same as ordinary mild steel. After a small amount of temper cold rolling it is said that stretcher strains do not occur even after aging as long as one year at room temperature. American Rolling Mill Co., Middletown, Ohio.

Page-Allegheny Alloys

Allegheny Metal and other Allegheny Alloys are now available in round, flat and shaped wire forms from the Page Steel & Wire Co., Monessen, Pa. Wire rope made from these alloys is available from the Hazard Wire Rope Co., Wilkes-Barre, Pa. Chains and chain attachments are supplied by the American Chain Co. plant at York, Pa. Welding wires, farm fence, barbed wire, traffic guard, strand wire, and other products are available from the Page Steel & Wire Co. American Chain Co., Bridgeport, Conn.

General Electric Switch

Small, hand-operated starting switch, Type CR1061, for use with single-phase a.c. or d.c. fractional horsepower motors, is said to provide protection against stalled rotor current and overload. Has a positive snap-action mechanism which is trip-free on overload. Molded parts are made

from Textolite, and contact tips are pure silver. Open-type switches are supplied with a knob for hand operation or with a splined shaft for switches mounted in explosion-proof inclosures. Inclosed-type of switch is mounted in a black-enameled, drawn steel case for wall mounting or flush mounting. Conduit knockouts are

provided in top and bottom, two conduit fittings being furnished. For Class I, Group D, hazardous locations, the open-type switch for spline-shaft operation is mounted in a heavy cast-iron case with machined flanges. General Electric Co., Schenectady, N. Y.

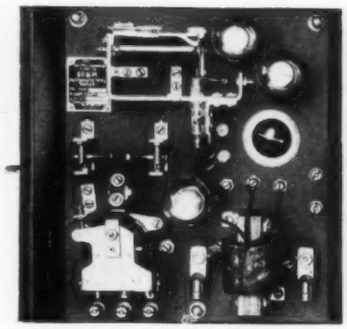
Vitrohm Ring-Type Rheostats

For control of fractional horsepower motors, filament circuits, or battery circuits, where a heavy-duty rheostat is required for fine continuous adjustment. Resistance wire having a low temperature coefficient of resistivity is wound around a base of refractory material and coated with a vitre-

ous enamel. Shaft is insulated from the contact lever and center bearing is provided with locknuts for single hole panel mounting. Rated at 100 watts continuous service with a temperature rise not exceeding 250 deg. C. Available with resistance values from 1 to 10,000 ohms. Extends back of panel $2\frac{3}{8}$ in., diameter $3\frac{1}{8}$ in. Ward Leonard Electric Co., Mount Vernon, N. Y.

Automatic Weld Timer

For controlling welding machines, varies the welding time in inverse proportion to the rate of current flow. Claimed to produce perfect welds regardless of fluctuations in line voltage, condition of electrodes, variations in thickness of material. Controller consists of a rectifier tube charging a fixed condenser in proportion to the rate of current flow in the welding circuit. When condenser charge reaches an amount sufficient to pass current through two gas-filled tubes, a small relay operates a second relay controlling the main line contactor. Controllers are also available with an additional time element controlling the length of time the electrodes are apart.



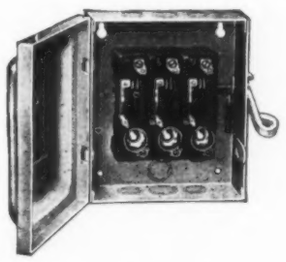
Another type is provided with a control to prevent the operator from separating the electrodes before the welding current has been interrupted. The illustration shows the weld timer with the door open. Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland, Ohio.

Minard Air Valve and Filter

Can be used with any double-acting air cylinder for returning compressed air from the exhaust side to the live side of the cylinder. Filter is designed to keep scale and dirt in the air line out of the valve. Oil mixed with the air in the form of a spray is said to provide lubrication and prevent rust. Air cylinder and valve are cleaned by opening the drain pipe. Can be used with the valve mounted in any position. Detroit Tool & Forge Co., 656 Smith Ave., Detroit, Mich.

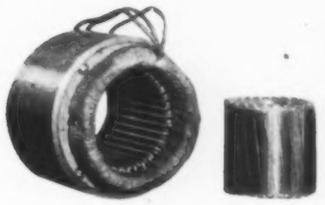
Arrow Type "D" Inclosed Switch

Has full-floating, self-adjusting, double-break contacts with spring throw-off and throw-on. Said to be easy to wire with plenty of room at top, bottom and sides. Supplied in satin finish aluminum. Arc is broken by fiber plates interposed between the stationary contacts. Available for plug fuses, cartridge fuses or unfused. Rated at 30 amp., 125 and 250 volts, and supplied in 2- and 3-pole types. Arrow Electric Division, The Arrow-Hart & Hegeman Electric Co., Hartford, Conn.



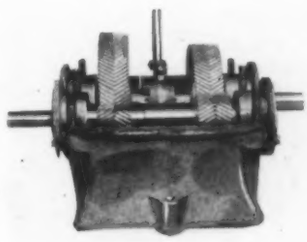
Ohio Can-Type A.C. Motors

Consist of stator and rotor for direct assembly into machine drive. Stators are completely wound with laminations exposed but turned to size, bakelite end pieces prevent bulging, and oil-resist-



ing insulation is used. Rotor cores are ground and balanced with straight bores and keyways but without keys or shafts. Available only for polyphase a.c., 110 to 550 volts, for 50 or 60 cycle. Furnished for speeds of 1,150, 1,750, and 3,500 in each of the following capacities: $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, and 2 hp. Some sizes also available for 25 cycle. Ohio Electric Mfg. Co., 5900 Maurice Ave., Cleveland, Ohio.

Twin Ratio Speed Reducers



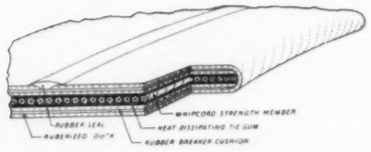
Are so constructed that either ratio may be used or the machine thrown into neutral by a speed change lever which operates a clutch. For driving conveyors requiring a fast and a slow speed, or where a standard variable-speed transmission does not provide the necessary range of speeds. Machine incorporates standard practice in regard to shafts and bearings and is designed with herringbone gears. Palmer-Bee Co., Detroit, Mich.

G.E. Photoelectric Relay

For operating magnetic counters, controlling mechanisms, starting and stopping machinery. Operates at a minimum light intensity of 3 foot-candles. Phototube housing with a cast aluminum base and aluminum

hood is connected to the relay with a flexible armored cable. Designed so that necessary adjustments can be made easily. Adjustment knob mounted on the bracket that supports the tube, and a two-position switch to cause relay to function with either admitted or interrupted light. Sensitive relay adjustment is accessible. General Electric Co., Schenectady, N. Y.

Condor Belt



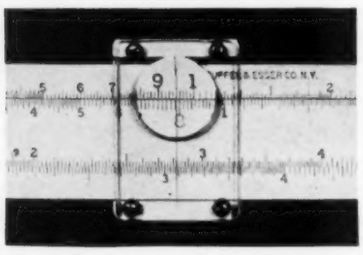
With an endless-wound whipcord construction is said to have no inelastic stretch. Single layer cord section is claimed to be equivalent in strength to six duck plies and to be more flexible. Said to be suitable for high tension drives. Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc., Passaic, N. J.

Oilproof Okocord

For use in machine shops, garages, refineries and oil wells where portable cords are subjected to attack of oil. Available in a full line of portable cords and cables having a special outer sheath impervious to oil or grease. Said to be but little affected by sunlight and ozone. The Okonite Co., Passaic, N. J.

Slide Rule Magnifier

Attached to the slider by suction, enlarges figures and division to twice actual size. Lens can be shifted readily from one scale to the other, leaving



one scale free for rough calculations. Said to be made from best optical glass, and to prevent eye strain. The Slip-Lens Co., 15 Charlton St., New York, N. Y.

Norma-Hoffmann "Pigmy" Bearings

Now included in the standard line are two small sizes: size N-463 with $\frac{1}{8}$-in. bore and $\frac{3}{8}$-in. outside diameter contains 12 balls; size 4666 with $\frac{3}{16}$-in. bore and $\frac{1}{2}$-in. outside diameter contains 17 balls. Diameter of ball is $\frac{1}{16}$ in. For use in precision instruments, scales, relays and light-duty applications requiring precision and sensitivity. Norma-Hoffmann Bearings Corp., Stamford, Conn.

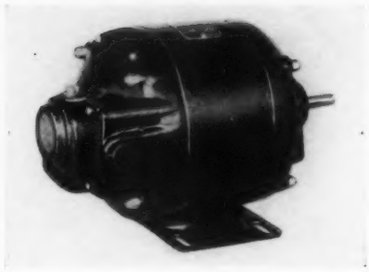
Furnas Drum Switch

For starting, stopping and reversing small motors. One-piece steel frame is fitted with a drawn steel top, flanged to make the case drip-proof. Spindle is of square section steel, insulated with square bakelite tubing. Rotor contacts

of hard-rolled copper are renewable. Cover is lined with asbestos. Two $\frac{1}{4}$-in. mounting holes are provided near the top, and two $\frac{1}{2}$-in. conduit openings are placed in the bottom of the case. No pigtails or cross connections are used. Interior metal parts and frame are cadmium-plated; top, cover, handle stem and cap are nickel finish. Handle knob is molded from red bakelite. For use with $\frac{1}{2}$ hp., a.c., or $\frac{1}{4}$ hp., d.c. motors on 110 or 220 volts. Over-all dimensions are 3x5x5 in. Furnas Electric Co., 1525 S. 77th St., West Allis, Wis.

General Electric Motor For Water Pumps

Is a single-phase, fractional-horsepower motor, Type RSA, having drip-proof end flanges designed to prevent dripping water from entering the motor. Oil capacity of bearings is claimed to be sufficient for one year. Built-in terminal box eliminates ne-



cessity for splicing and soldering connections. Performance characteristics are in accordance with N.E.M.A. standards for short annual service. Available in $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{3}$-hp. ratings, with interchangeable mounting dimensions. General Electric Co., Schenectady, N. Y.

Sprayed Izarine

Is a suede-like finish applied by spraying an enamel coat followed by a coat of Izarine powder applied with an air gun. The enamel is said to remain wet long enough to allow time for spraying on the powder and then dries rapidly without requiring baking. Zapon Co., Stamford, Conn.

Westinghouse Mercury Switch

Is totally inclosed and hermetically sealed, safe for use in vapor-filled rooms, gasoline pumps, spraying equipment; and is refractory protected to confine the arc. Contact is made by an impact between two pools of mercury within a refractory chamber incased in heavy glass. An atmosphere of inert gas is said to dissipate the heat of the arc, keep the mercury chemically pure and prevent it from becoming gummy and slow flowing. Available in six ratings from 3 amp. to 50 amp., as shown in the table, with flexible leads from 6 to 8 in. long. Special mounting clips are supplied to facilitate installation. The contact

wires which pass through the glass press are the same as those used in high power lamps and radio transmitting tubes. Westinghouse Lamp Co., Bloomfield, N. J.

Nominal Rating Amp.	Angle of Operation Range	Outside Diameter In.	Over-all Length In.
3	3 to 8 deg.	0.41 to 0.48	2 7/16
10	15 to 29 deg.	0.61 to 0.65	2
10	6 to 15 deg.	0.61 to 0.65	3 1/4
20	6 to 15 deg.	0.95 max.	3 13/16
30	6 to 15 deg.	0.95 to 1.07	4 1/16
50	30 deg.	1.08 to 1.27	4 1/16

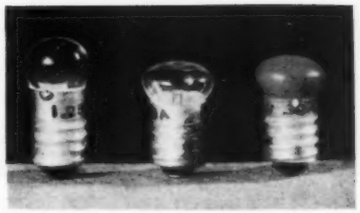
Type 2 Motor-Operated Controller

A two-position type for operating valves, dampers, rheostats. A minimum adjustment can be provided to permit any desired minimum setting up to 50 per cent of valve capacity. Where full pipe line capacity is required, and tight shut off essential, controller is supplied to operate valves of the globe body type in sizes up to 3 in. for pressures up to 250 lb. per sq.in. At lower pressures, larger valves can be operated. Controller has sufficient power to handle an air valve up to 4-in. size in combination with a ½-in. fuel oil

valve, or two valves up to 4-in. size on low-pressure gas and air. Claimed that the fuel-air ratio is maintained throughout the stroke, since both fuel and air valves are moved in unison. Controller is designed so that the valves can be quickly converted to manual operation by removing the fulcrum stud. Automatic Temperature Control Co., Inc., 34 E. Logan St., Philadelphia, Pa.

General Electric Toy Lamps

Two new lamps rated at 1.25 volts and 0.3 amperes for use with one or more battery cells are now available. Mazda lamp No. 11 is made with clear, red, or green coated bulbs. Mazda



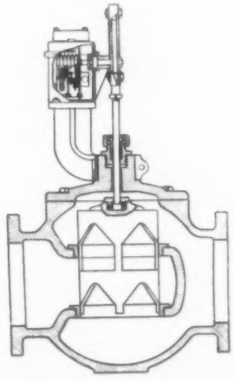
lamp No. 22 has a solid glass lens providing a concentrated beam of light. Where space does not permit use of two batteries the 1.25 volt lamp has a light output five times greater than the 2.5 volt lamp operated on a single cell battery. Where two cells can be used a multiple connection using the new lamp is said to be preferable to a series arrangement with the 2.5 volt lamps. General Electric Co., Nela Park, Cleveland, Ohio.

"Lectrovac" Chemicalware

In extruded shapes, such as piping, pump liners and plungers, rolls, packing rings. A combination of electrolytic, chemical and mechanical processing is said to produce a material possessing greater strength, density and resistance to thermal and mechanical shocks. During mixing, clays are subjected to an electrolytic and magnetic treatment. A new body constituent is said to improve thermal shock. Removal of air in large vacuum chambers is said to reduce drying strain. United States Stoneware Co., 50 Church St., New York, N. Y.

Barber-Colman Motor-Operated Valves

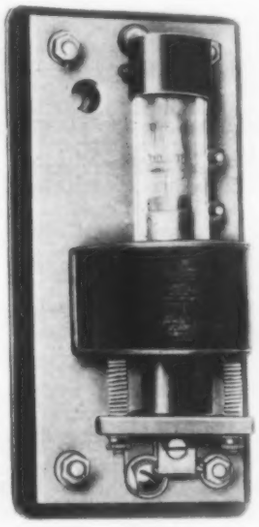
Now available in sizes larger than 2 in. for remote automatic or manual control. The full-balanced piston-disk model illustrated is said to provide a 12-in. valve good for pressure up to 125 lb. Valves are supplied in three types. A single-seat type with renewable composition disk, available in



sizes from 2 in. to 6 in., is designed to handle pressures from 80 lb. to 9 lb., depending on the size, and is made with either positive or reversing motor operators. Semi-balanced double bronze disk type is made with V-port disk in 2-in. to 4-in. sizes and with standard disk in the 5-in., 6-in., and 8-in. sizes, either positive or reversing for 125 lb. pressure. The full-balanced type is made in sizes from 5 in. to 12 in. with reversing operators only, and for pressures up to 125 lb. Barber-Colman Co., Rockford, Ill.

Mercrelay

Is a displacement type of mercury switch claimed to have indefinite life when used within rated limits, to be safe in the presence of combustible material, and silent in operation. A heavy wall glass tube provided with bakelite end caps has an electrode at the bottom that makes contact with the mercury pool. The top electrode has a fused quartz cup partially immersed in the mercury pool. Floating on the mercury is a magnetic tube which is drawn down by energizing an electrical coil fixed around the glass tube, thus raising the level of the mercury pool so that it merges with the mercury in the quartz cup, completing the circuit. When the coil is



de-energized, the magnetic member again floats, and the main mercury pool separates from that in the cup, the arc occurring around the edge of the quartz cup. Available normally open or closed, operating on 9 watts. Rated at 25 amp., 220 V., a.c., or d.c., non-inductive load. Height, 5 in.; width, 3⅝ in.; depth, 3½ in. General Wire & Switch Co., 140 Benedict St., Providence, R. I.

NEW BOOKS and PUBLICATIONS

"Electron Tubes"

John H. Morecroft, 458 pages, 6x9 in. 536 figures. Clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $4.50.

This is not an abstruse scientific treatment, but a textbook in engineering language and devoted to the application of electron devices in engineering problems. The free use of illustrations, diagrams, drawings, sketches and charts results in a style of presentation to which engineers are accustomed.

The first three chapters set forth the fundamentals of electron flow, and include historical data. Four succeeding chapters provide detailed information on the form, construction and electrical characteristics of such electron devices as hot cathode, photo-electric, grid controlled rectifier and mercury rectifier tubes. A chapter on the uses of these electron devices describes a number of practical applications in detail. The last nine chapters contain explicit information as to performance, limitations, and electrical circuits required in the application of three element tubes as power converters, amplifiers, oscillators and modulators.

The text suggests many opportunities for using electron tubes; the illustrations and diagrams are of value in applying the devices.

"Standards and Specifications"

Encyclopedia of Specifications, Vol. 3, "Standards and Specifications for Metals and Metal Products." Compiled by the Bureau of Standards, U.S. Department of Commerce. Ten chapters, 1359 pages, 7⅝x10⅝ in. Bound in green buckram. For sale by the Superintendent of Documents, Washington, D.C. Price $3.

This third volume of the Encyclopedia of Specifications, which has been under compilation by the Bureau of Standards for several years, will be found valuable as a guide for the specification of metals and metal products. Instead of descriptive titles, the encyclopedia reproduces actual copies or gives in suitable abstract form the standards and specifications relating to ores, metals and manufactures, (except machinery, vehicles, and electrical supplies) formulated by the national technical societies, trade associations or other organizations. Included are all commodities embraced in the numerical classification designation 600-699 in the National Directory of Commodity Specifications.

Contents of this encyclopedia include the following: More than 1,600 nationally recognized standards and specifications; methods of testing, chemical analyses, metallic coatings, and heat-treatment of metals in considerable detail; 1,100 illustrations; 2,000 cross references to demonstrate the close relationship existing among the specifications assigned to the metals; 1,700 tables; an extended index of approximately 3,500 items containing all references to any metallic commodity referred to in these 1,600 specifications, so that comparisons may be readily made between the specification requirements of the various specification-producing organizations; a list of technical societies, trade associations, and other organizations issuing standards and specifications for metals and metal products.

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Air Valves — Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. Bulletin YB-2001, 4 pages, "The Yarway-Becker Automatic Control Valve for Compressed Air Lines."

Bakelite—Bakelite Corp., 247 Park Ave., New York, N. Y. In a small 16-page booklet, "The Versatile Service of Bakelite Resinoid," is an excellent description of manufacturing methods used in making bakelite and bakelite products.

Ball Bearings—New Departure Mfg. Co., Bristol, Conn. Data Sheet No. 203 FE, "Variable Stroke Hydraulic Pump," describing use of ball bearings.

Bronze — Bridgeport Brass Co., Bridgeport, Conn., 24-page booklet, "Duronze." Physical properties, corrosion resistance, fabrication of three silicon bronze alloys.

Contactors — Sarvas Electric Co., Inc., 22-14 40th Ave., Long Island City, N. Y. Bulletin No. 103, 4 pages, "Sarvas Silent A.C. Contactors," describing contactors operated by rectified a.c.

Expansion Joints — Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. Bulletin EJ-1904, 16 pages, "Yarway Expansion Joints," technical data, details, specifications for various types.

Fuse Links—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Leaflet L-20553, 4 pages, "Type LT Universal Fuse Links," application, construction, operation.

Gear-motor—General Electric Co., Schenectady, N. Y., four-page bulletin GEA-1765, "G-E Fractional-horsepower Gear-Motors." Construction and application of concentric shafts and right-angle shaft type.

Micro Switch—C. F. Burgess Laboratories, Inc., 202 E. 44th St., New York, N. Y. Leaflet, 4 pages, "Burgess Micro Switch," with details of construction, applications, and types available.

Nitralloy—Ludlum Steel Co., Watervliet, N. Y. Booklet, 34 pages, "Nitralloy and the Nitriding Process," analysis and physical properties, heat-treating and nitriding operations, properties of a nitrided case, and nitriding equipment.

Photoelectric Relay—General Electric Co., Schenectady, N. Y. Four-page leaflet GEA-1755, "CR7505-K1 Photoelectric Relay," with performance, illumination data, application and accessories.

Rectifiers—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Leaflet 20571, 4 pages, "Copper Oxide Rectifying Units," construction, operation, performance, specifications.

Reduction Gears—Poole Foundry & Machine Co., Woodberry, Baltimore, Md. Catalog, 36 pages, "Reduction Gears," with dimension sheets and tables of weights, horsepower ratings, speeds, ratios.

Relay—Ward Leonard Electric Co., Mt. Vernon, N. Y. Bulletin 106, 2 pages, "Midget Magnetic Relays." Catalog information, circuit diagrams, contact arrangements.

Resistors—Ward Leonard Electric Co., Mt. Vernon, N. Y., 20-page catalog including Bulletins 11, 19 and 25, "Vitrohm and Ribflex Resistors."

Roller Bearings — Tyson Roller Bearing Corp., Massillon, Ohio. Recommendations and engineering data for application of Tyson cageless tapered roller bearings in mine and quarry cars.

Speed Reducers—D. O. James Mfg. Co., 1120 W. Monroe St., Chicago, Ill. Bulletin 11, 48 pages, with details of design and rating charts for bevel gears and speed reducers.

Stainless Steel & Iron — Latrobe Electric Steel Co., Latrobe, Pa. Handbook, 103 pages, with instructions for forging, and heat-treatment; physical properties and corrosion resistance for stainless steel, stainless iron, and weight data also included.

Steel—Lebanon Steel Foundry, Lebanon, Pa. Booklet, 8 pages, "Alloy Steel Castings," giving physical properties and applications for a number of high-strength, heat-resistant, and corrosion-resistant steels.

Wire Cloth — International Nickel Co., 67 Wall St., New York, N. Y. Booklet, 8 pages, on the selection of wire cloth in paper, petroleum, food, dry cleaning, paint and rubber manufacture.

Horsepower Capacities of Straight Bevel Gears—II

(PER INCH OF FACE WIDTH)

Six tables on the horsepower capacities of straight bevel gears, together with an explanation of the use of these tables, were given on pp. 239 and 240 of the June number of *Product Engineering*. That article also gives a table of factors by which the pinion pitch diameter or the gear pitch diameter can be multiplied to get the length of tooth face that will equal one-third the slant height of the pitch cone. The accompanying seven tables complete this series

▼

4—Diametral Pitch

R.P.M.		Number of Teeth							
		12	14	16	20	25	30	50	100
2400	V.	1890	2200	....	....	....	....	....	....
	H.P.	3.95	4.5	....	....	....	....	....	....
1800	V.	1415	1650	1890	2360	....	....	....	....
	H.P.	3.60	4.3	4.7	5.5	....	....	....	....
1200	V.	945	1100	1260	1570	1965	2360	....	....
	H.P.	3.20	3.75	4.2	4.9	5.7	6.1	....	....
900	V.	710	825	945	1180	1475	1770	....	....
	H.P.	2.80	3.35	3.80	4.5	5.3	5.7	....	....
600	V.	470	550	630	785	985	1180	1965	....
	H.P.	2.30	2.73	3.20	3.95	4.6	5.1	6.4	....
450	V.	355	410	470	590	740	885	1475	....
	H.P.	1.93	2.34	2.74	3.40	4.1	4.6	5.9	....
300	V.	235	275	315	395	490	590	985	1965
	H.P.	1.47	1.80	2.14	2.74	3.35	3.80	5.2	6.9
200	V.	157	183	210	260	330	395	655	1310
	H.P.	1.07	1.34	1.63	2.06	2.63	3.05	4.4	6.1
150	V.	118	137	157	197	245	295	490	985
	H.P.	.85	1.07	1.29	1.70	2.14	2.54	3.80	5.5
100	V.	79	92	105	131	164	196	330	655
	H.P.	.59	.75	.94	1.23	1.59	1.89	3.00	4.7
50	V.	39.0	45.5	52	66	82	98	164	330
	H.P.	.294	.375	.47	.64	.87	1.08	1.80	3.20
10	V.	7.9	9.2	10.5	13.1	16.4	19.6	33.0	66
	H.P.	.059	.075	.094	.127	.173	.214	.395	.84

5—Diametral Pitch

R.P.M.		Number of Teeth							
		12	14	16	20	25	30	50	100
2400	V.	1510	1760	2010	....	....	....	....	....
	H.P.	3.00	3.40	3.85	....	....	....	....	....
1800	V.	1130	1320	1510	1885	2360	....	....	....
	H.P.	2.74	3.15	3.60	4.1	4.7	....	....	....
1200	V.	755	880	1010	1260	1570	1885	....	....
	H.P.	2.34	2.74	3.15	3.65	4.3	4.6	....	....
900	V.	565	660	755	945	1180	1415	2360	....
	H.P.	2.03	2.40	2.80	3.35	3.95	4.3	5.3	....
600	V.	380	440	505	630	785	945	1570	....
	H.P.	1.61	1.93	2.26	2.80	3.35	3.75	4.9	....
450	V.	285	330	380	470	590	710	1180	2360
	H.P.	1.35	1.63	1.93	2.40	2.94	3.35	4.5	5.7
300	V.	189	220	250	315	390	470	785	1570
	H.P.	1.00	1.23	1.47	1.88	2.34	2.74	3.80	5.1
200	V.	126	147	168	210	260	315	525	1050
	H.P.	.72	.90	1.09	1.43	1.79	2.14	3.15	4.5
150	V.	94	110	126	157	196	235	390	785
	H.P.	.56	.72	.87	1.13	1.45	1.73	2.60	4.1
100	V.	63	73	84	105	131	157	260	525
	H.P.	.375	.49	.60	.82	1.06	1.25	2.00	3.35
50	V.	31.5	36.5	42.0	52	66	79	131	260
	H.P.	.187	.243	.300	.41	.55	.69	1.19	2.17
10	V.	6.3	7.3	8.4	10.5	13.1	15.7	26.2	52
	H.P.	.037	.049	.060	.082	.111	.139	.250	.53

6—Diametral Pitch

R.P.M.		Number of Teeth							
		12	14	16	20	25	30	50	100
3600	V.	1880	2200	....	....	....	....	....	....
	H.P.	2.63	3.00	....	....	....	....	....	....
2400	V.	1260	1470	1680	2100	....	....	....	....
	H.P.	2.34	2.67	3.05	3.55	....	....	....	....
1800	V.	945	1100	1260	1570	1970	2360	....	....
	H.P.	2.14	2.47	2.80	3.35	3.80	4.1	....	....
1200	V.	630	735	840	1050	1310	1570	....	....
	H.P.	1.77	2.10	2.43	2.94	3.40	3.75	....	....
900	V.	470	550	630	785	985	1180	1970	....
	H.P	1.52	1.84	2.14	2.60	3.05	3.40	4.3	....
600	V.	315	365	420	525	655	785	1310	....
	H.P.	1.19	1.44	1.72	2.14	2.57	2.94	3.80	....
300	V.	157	183	210	260	330	390	655	1310
	H.P.	.72	.89	1.08	1.37	1.75	2.03	2.94	4.1
200	V.	105	122	140	175	220	260	435	875
	H.P.	.52	.64	.79	1.03	1.32	1.49	2.34	3.55
150	V.	79	92	105	131	164	197	330	655
	H.P.	.395	.50	.63	.82	1.05	1.26	1.98	3.15
100	V.	52	61	70	87	109	131	220	435
	H.P.	.260	.335	.42	.57	.77	.92	1.49	2.50
50	V.	26.2	30.5	35.0	43.5	55	66	109	220
	H.P.	.130	.167	.210	.286	.385	.48	.87	1.60
10	V.	5.2	6.1	7.0	8.7	10.9	13.1	21.8	43.5
	H.P.	.026	.033	.042	.057	.077	.096	.176	.365

PRODUCT ENGINEERING © REFERENCE BOOK SHEET

Horsepower Capacities of Straight Bevel Gears—II

(PER INCH OF FACE WIDTH)

7—Diametral Pitch

R.P.M.		Number of Teeth							
		12	14	16	20	25	30	50	100
3600	V.	1620	1890	2160	....	....	....	....	....
	H.P.	2.17	2.47	2.80	....	....	....	....	....
2400	V.	1080	1260	1440	1800	2240	....	....	....
	H.P.	1.92	2.20	2.54	2.94	3.35	....	....	....
1800	V.	810	945	1080	1350	1680	2020	....	....
	H.P.	1.71	2.00	2.30	2.74	3.15	3.40	....	....
1200	V.	540	630	720	900	1120	1350	2240	....
	H.P.	1.41	1.67	1.95	2.34	2.74	3.05	3.80	....
900	V.	405	470	540	675	840	1010	1680	....
	H.P.	1.20	1.43	1.69	2.07	2.47	2.80	3.55	....
600	V.	270	315	360	450	560	675	1120	2250
	H.P.	.93	1.13	1.33	1.68	2.04	2.34	3.15	4.1
300	V.	135	157	180	225	280	335	560	1120
	H.P.	.55	.67	.83	1.07	1.35	1.57	2.30	3.35
200	V.	90	105	120	150	187	225	375	750
	H.P.	.380	.49	.59	.79	1.00	1.20	1.85	2.80
150	V.	67	79	90	112	140	168	280	560
	H.P.	.286	.365	.46	.61	.80	.96	1.52	2.46
100	V.	45.0	52	60	75	94	112	187	375
	H.P.	.190	.246	.305	.42	.57	.70	1.13	1.96
50	V.	22.5	26.2	30.0	37.5	47.0	56	94	187
	H.P.	.095	.123	.153	.210	.285	.355	.64	1.21
10	V.	4.5	5.2	6.0	7.5	9.4	11.2	18.7	37.5
	H.P.	.019	.025	.031	.042	.057	.070	.129	.274

8—Diametral Pitch

R.P.M.		Number of Teeth							
		12	14	16	20	25	30	50	100
3600	V.	1410	1650	1890	2360	....	....	....	....
	H.P.	1.84	2.10	2.36	2.74	....	....	....	....
2400	V.	945	1100	1260	1570	1960	2360	....	....
	H.P.	1.59	1.85	2.10	2.46	2.80	3.05	....	....
1800	V.	710	825	945	1180	1476	1770	....	....
	H.P.	1.41	1.65	1.91	2.26	2.64	2.86	....	....
1200	V.	470	550	630	785	985	1180	1960	....
	H.P.	1.14	1.37	1.60	1.93	2.30	2.54	3.20	....
900	V.	355	415	470	590	735	885	1470	....
	H.P.	.97	1.17	1.37	1.70	2.04	2.30	3.00	....
600	V.	235	275	315	395	490	590	985	1970
	H.P.	.73	.90	1.07	1.36	1.65	1.91	2.60	3.40
300	V.	118	138	157	197	245	295	490	985
	H.P.	.43	.53	.65	.85	1.07	1.27	1.88	2.80
200	V.	79	92	105	131	164	197	330	655
	H.P.	.294	.375	.47	.61	.79	.95	1.49	2.34
150	V.	59	69	79	98	123	147	245	490
	H.P.	.220	.280	.355	.48	.63	.76	1.21	2.00
100	V.	39.5	46.0	52	66	82	98	164	330
	H.P.	.147	.188	.234	.320	.43	.54	.90	1.59
50	V.	19.7	23.0	26.0	33.0	41.0	49.0	82	164
	H.P.	.073	.094	.117	.160	.216	.266	.49	.97
10	V.	....	....	....	....	....	9.8	16.4	33.0
	H.P.	....	....	....	....	....	.054	.099	.214

10—Diametral Pitch

R.P.M.		Number of Teeth							
		12	14	16	20	25	30	50	100
3600	V.	1130	1320	1510	1890	2360	....	....	....
	H.P.	1.36	1.57	1.79	2.06	2.36	....	....	....
2400	V.	755	880	1000	1260	1570	1890	....	....
	H.P.	1.16	1.36	1.56	1.85	2.14	2.34	....	....
1800	V.	565	660	755	945	1180	1410	2360	....
	H.P.	1.01	1.20	1.39	1.67	1.96	2.16	2.66	....
1200	V.	380	440	500	630	785	945	1570	....
	H.P.	.81	.97	1.13	1.40	1.68	1.88	2.44	....
900	V.	280	330	380	470	590	705	1180	2360
	H.P.	.66	.81	.97	1.21	1.47	1.67	2.24	2.86
600	V.	189	220	250	315	395	470	785	1570
	H.P.	.50	.61	.73	.94	1.17	1.35	1.91	2.56
300	V.	94	110	126	157	197	235	395	785
	H.P.	.280	.360	.43	.57	.73	.87	1.32	2.04
200	V.	63	73	84	105	131	157	260	525
	H.P.	.187	.240	.300	.41	.53	.64	1.01	1.67
150	V.	47.0	55	63	79	98	118	197	395
	H.P.	.140	.179	.226	.305	.41	.51	.83	1.41
100	V.	31.5	37.0	42.0	53	66	79	131	266
	H.P.	.093	.119	.150	.206	.274	.345	.60	1.08
50	V.	15.7	18.3	21.0	26.2	33.0	39.5	65	131
	H.P.	.047	.060	.075	.103	.137	.173	.315	.64
10	V.	....	....	....	....	....	....	13.1	26.2
	H.P.	....	....	....	....	....	....	.063	.133

12—Diametral Pitch

R.P.M.		Number of Teeth							
		12	14	16	20	25	30	50	100
3600	V.	945	1100	1260	1570	1970	2360	....	....
	H.P.	1.06	1.23	1.41	1.65	1.89	2.04	....	....
2400	V.	630	735	840	1050	1310	1570	....	....
	H.P.	.89	1.05	1.22	1.45	1.69	1.86	....	....
1800	V.	470	550	630	785	985	1180	1970	....
	H.P.	.76	.91	1.07	1.30	1.53	1.70	2.14	....
1200	V.	315	365	420	525	655	785	1310	....
	H.P.	.60	.72	.86	1.07	1.29	1.46	1.92	....
900	V.	235	275	315	390	490	590	985	1970
	H.P.	.49	.60	.72	.90	1.11	1.27	1.73	2.26
600	V.	157	183	210	260	330	390	655	1310
	H.P.	.360	.45	.54	.69	.87	1.02	1.46	2.04
300	V.	79	92	105	131	163	197	330	655
	H.P.	.196	.250	.315	.41	.53	.63	.99	1.55
200	V.	52	61	70	87	109	131	220	435
	H.P.	.131	.167	.206	.286	.380	.46	.75	1.25
150	V.	39.0	46.0	52	66	82	98	164	330
	H.P.	.098	.125	.156	.214	.286	.360	.59	1.06
100	V.	26.2	30.5	35.0	43.5	55	66	109	220
	H.P.	.065	.083	.104	.141	.192	.240	.43	.80
50	V.	13.1	15.3	17.5	21.8	27.3	33.0	55	109
	H.P.	.033	.041	.052	.071	.096	.120	.216	.46
10	V.	....	....	....	....	....	....	10.9	21.8
	H.P.	....	....	....	....	....	....	.043	.093

Contributed by C. H. Grill

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